NDIA

2018 HUMAN SYSTEMS CONFERENCE

HUMAN SYSTEMS IN EMERGING DOMAINS: AUTONOMY, HUMAN AUGMENTATION, AND CYBER

March 13 – 14, 2018

Waterford at Springfield

Springfield, VA

NDIA.org/HumanSystems18

WELCOME TO THE 2018 HUMAN SYSTEMS CONFERENCE

Welcome. The 2018 Conference of the NDIA Human Systems Division (HSD) is designed to serve the Department of Defense and strengthen the defense industry. This is the mission of the NDIA and its members: 1,600 corporations and 85,000 individuals. The HSD conference supports the mission by bringing DoD S&T leadership, representatives of industry, and other guests into discussion over accomplishments of DoD human systems research and development, gaps in DoD human systems, and emerging research and technology that can bridge those gaps. This conference is a small and vital forum for all of us to learn, to envision new solutions, and to build the relationships and opportunities to collaborate.

The NDIA Human Systems Division is chartered to support the DoD Human Systems Community of Interest (HS COI). Our subcommittee structure (represented by the list of technical sessions in this program) is identical that of the HS COI, with the exception of one addition: this Division has established a subcommittee on Human Systems Metrics to help assess and promote the value of human systems research and development, techniques, and technologies. The leaders of our five subcommittees plan this conference, participate in studies for DoD, and grow the Human Systems community. I urge you to join one of the Division's subcommittees. To pursue that opportunity, contact NDIA, or talk to any of the Human Systems Division subcommittee co-chairs at this conference.

Thanks to the team that organized our conference: the conference co-chairs, LCDR Jacob N. Norris, Ph.D., and Eric Jones; their team members on the HSD sub-committee co-chairs; and the professional staff of NDIA. Thanks also to the representatives of the DoD Human Systems Community of Interest, who have joined us at this event. A special note of appreciation to our sponsors: Ball Aerospace, Rockwell Collins, and DCS Corporation. Finally, welcome to all of you who have come here to understand, improve, and accelerate the research and development of better human systems for the Department of Defense.

Respectfully,

Jared Freeman, Ph.D.
Chair, NDIA Human Systems Division
Chief Scientist, Aptima, Inc.

SCHEDULE AT A GLANCE

TUESDAY, MARCH 13

General Session
Singleton/Miller Ballroom
8:00 am – 5:00 pm

Networking Poster and Demonstration Session
von Sternberg/Hazel Ballroom
1:15 – 3:15 pm

Networking Reception
Waterford Foyer
5:00 – 6:30 pm

WEDNESDAY, MARCH 14

General Session
Singleton/Miller Ballroom
8:00 am – 5:00 pm

Round Table Discussion
Singleton/Miller Ballroom
3:15 – 4:45 pm

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WHO WE ARE

The National Defense Industrial Association is the trusted leader in defense and national security associations. As a 501(c)(3) corporate and individual membership association, NDIA engages thoughtful and innovative leaders to exchange ideas, information, and capabilities that lead to the development of the best policies, practices, products, and technologies to ensure the safety and security of our nation. NDIA's membership embodies the full spectrum of corporate, government, academic, and individual stakeholders who form a vigorous, responsive, and collaborative community in support of defense and national security. For more information, visit **NDIA.org**

HUMAN SYSTEMS DIVISION

WHO WE ARE

NDIA's Human System Division promotes the exchange of technical information and discussions between government, industry and academia, and the expansion of research and development in areas related to the human as a system whose performance must be integrated into any military system of systems. To this end, the division will serve as an infrastructure by providing a variety of ways for government, industry and academia to collaborate to advance human performance in air, land, see, space and cyberspace through research, education and consultation.

LEADERSHIP AND COMMITTEES

Dr. Jared Freeman
Human Systems Chair
Chief Scientist, Aptima, Inc.

BG Peter Palmer, USA (Ret)
Human Systems Vice Chair
President, P2 Consulting Services

Scott Kozak
Human Systems Deputy Chair
Managing Director, CogniSens Applied Research Center

EVENT INFORMATION

EVENT WEBSITE

NDIA.org/HumanSystems18

EVENT CONTACT

Andrea Lane
Meeting Planner
(703) 247–2554
alane@ndia.org

EVENT THEME

Human Systems in Emerging Domains: Autonomy, Human Augmentation and Cyber

CONFERENCE LEADERSHIP

Eric Jones
Industry Chair

LCDR Jake Norris, USN
Government Chair

SESSION CHAIRS

Brad Chedister
Industry Co-Chair, PS&WP

Glenn Gunzelmann
Government Co-Chair, PAE&T

Dr. Kelly Hale
Industry Lead, HSM

Dr. James McCarthy
Industry Co-Chair, PAE&T

Dr. Todd Nelson
Government Co-Chair, SI&CP

CDR Henry Phillips, USN
Government Co-Chair, HI3Lead

George Salazar
Government Lead, HSM

Peter Squire
Government Co-Chair, PS&WP

SURVEY AND PARTICIPANT LIST

A survey and list of attendees (name and organization only) will be emailed to you after the conference. NDIA would appreciate your time in completing the survey to help make our event even more successful in the future.

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AGENDA

TUESDAY, MARCH 13

7:00 am – 6:00 pm

REGISTRATION
VON STERNBERG/HAZEL FOYER

7:00 – 8:00 am

NETWORKING BREAKFAST
MILLER/VON STERNBERG FOYER

8:00 – 8:15 am

WELCOME AND INTRODUCTORY REMARKS
SINGLETON/MILLER BALLROOM

Dr. Jared Freeman
Human Systems Division Chair
Chief Scientist, Aptima, Inc.

8:15 – 9:00 am

KEYNOTE ADDRESS
SINGLETON/MILLER BALLROOM

Dr. Brian Pierce
Office Director, Information Innovative Office (I2O)
Defense Advanced Research Projects Agency (DARPA)

9:00 – 10:30 am

PANEL: HUMAN SYSTEMS INTERFACE RESEARCH AND DEVELOPMENT CHALLENGES – GOVERNMENT PERSPECTIVE
SINGLETON/MILLER BALLROOM

LCDR Peter Walker, USN
Military Deputy, Human and Bioengineered Systems, Code 341, Office of Naval Research
Moderator

Laurie Fenstermacher
Principal Research Lead Open Source Analysis, 711 HPW/RHXM

Glenn Gunzelmann
Senior Research Psychologist, Air Force Research Laboratory

Dr. Todd Nelson
Division Chief, 711 HPW/AFRL

Peter Squire
Program Officer, Office of Naval Research

10:30 – 11:00 am

NETWORKING BREAK

MILLER/VON STERNBERG FOYER

11:00 – 11:05 am

INTRODUCTION TO TECHNICAL SESSION

SINGLETON/MILLER BALLROOM

Eric Jones
Conference Industry Chair, NDIA Human Systems Division
Human Systems Architect, The Charles Stark Draper Laboratory, Inc.

11:05 am - 12:15 pm

SESSION 1: PROTECTION, SUSTAINMENT AND WARFIGHTER PERFORMANCE (PS&WP)

SINGLETON/MILLER BALLROOM

Collaboration for Breakthrough Innovation in Human Performance Monitoring for the Warfighter

Dr. Melissa Grupen-Shemansky
SEMI-Flex, Tech

FitForce Planner: Optimizing USMC Physical Fitness

Timothy Clark
Aptima, Inc.

Transitioning Laboratory Neuroscience to the Real–World through Deep Learning: Using Evoked Potentials to Assess State

Dr. Stephen Gordon
DCS Corporation

Optimizing Future Soldier Systems through the Incorporation of Human Aspects into the Soldier as a System Domain using the Systems Modeling Language

Sean Pham
U.S. Army ARDEC

12:15 – 1:15 pm

NETWORKING LUNCH

VON STERNBERG/HAZEL BALLROOM

1:15 – 3:15 pm

NETWORKING POSTER AND DEMONSTRATION SESSION

VON STERNBERG/HAZEL BALLROOM

3:15 – 3:30 pm

REFRESHMENT BREAK

MILLER/VON STERNBERG FOYER

3:30 – 4:40 pm

SESSION 2: HUMAN SYSTEMS METRICS (HSM)

SINGLETON/MILLER BALLROOM

Human Systems Metrics Applied to Optimize Warfighter Capability

Sarah Orr
711 HPW/HP

Realizing Our Collective Vision by 2025: Leveraging Advances in Artificial Intelligence and Autonomy with Human Systems Advances in Human–Machine Symbiosis to Realize Our Roadmap to the Future

Dr. Denise Nicholson
Soar Technology, Inc.

Usability Scorecard

Deidrick Capers
Millennium Corporation

Julia Ruck
PM DCGS-A

HSI T&E Methods and Metrics to Assess User–Automation Interaction

Dr. Janae Lockett-Reynolds
DHS

4:40 – 5:00 pm

DAY 1 WRAP UP

SINGLETON/MILLER BALLROOM

Dr. Jared Freeman
Human Systems Division Chair
Chief Scientist, Aptima, Inc.

5:00 – 6:30 pm

NETWORKING RECEPTION (CASH BAR)

WATERFORD FOYER

WEDNESDAY, MARCH 14

7:00 am – 3:00 pm

REGISTRATION

VON STERNBERG/HAZEL FOYER

7:00 – 8:00 am

NETWORKING BREAKFAST

MILLER/VON STERNBERG FOYER

8:00 – 8:05 am

WELCOME REMARKS

SINGLETON/MILLER BALLROOM

Dr. Jared Freeman
Human Systems Division Chair
Chief Scientist, Aptima, Inc.

8:05 – 9:00 am

PLENARY ADDRESS

SINGLETON/MILLER BALLROOM

Dr. Paul Zablocky
Division Director, Complex Hybrid Warfare Sciences Division, Expeditionary Maneuver Warfare and Combating Terrorism Science and Technology Department, Office of Naval Research

9:00 – 10:10 am

PANEL: HUMAN SYSTEMS INTEGRATION METRICS

SINGLETON/MILLER BALLROOM

Dr. John Tangney
Director, Human & Bio-Engineered Systems, Office of Naval Research
Moderator

Rick Craft
Systems Analyst & Principal Member of the Technical Staff, Sandia National Laboratory

Dr. Kelly Hale
Senior Vice President, Technical Operations, Design Interactive, Inc.

BG Peter Palmer, USA (Ret)
President, P2 Consulting Services

John Plaga
Aerospace Engineer, 711 HPW/HPIF

10:10 – 10:40 am

NETWORKING BREAK

MILLER/VON STERNBERG FOYER

10:40 – 11:50 am

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SINGLETON/MILLER BALLROOM

Virtual and Augmented Reality for Training and Cognitive Aides

Peggy Wu
United Technologies Research Center

Developing a Predictive Model of Army Marksmanship Performance

Dr. Gregory Goodwin
U.S. Army Research Laboratory

Man vs. Machine: Comparing Traditional versus Big Data and Machine Learning to Predict Expertise

Dr. Krista Ratwani
Aptima, Inc.

Perceptual–Cognitive and Physiological Assessment of Training Effectiveness

Amy Diderksen
Rockwell Collins Simulation & Training Solutions

11:50 am – 12:45 pm

NETWORKING LUNCH

VON STERNBERG/HAZEL BALLROOM

12:45 – 1:55 pm

SESSION 4: SYSTEMS INTERFACE AND COGNITIVE PROCESSING (SI&CP)

SINGLETON/MILLER BALLROOM

Towards Natural Dialogue with Robotics: ARL Bot Language

Dr. Matthew Marge
U.S. Army Research Laboratory

VR Technologies for Next–Generation Battle Management Command and Control

Dr. Erin Cherry
Northrop Grumman Mission Systems

Developing an Autonomous Task Manager for Intelligence, Surveillance, and Reconnaissance Human–Machine Teams

Jennifer Lopez
711 HPW/RHXM

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Dr. Kristin Divis
Sandia National Laboratories

1:55 – 3:00 pm

SESSION 5: HUMAN INFORMATION, INTERPRETATION AND INFLUENCE (HI3)

SINGLETON/MILLER BALLROOM

Panel: Operations in the Information Environment

Laurie Fenstermacher
Principal Research Lead Open Source Analysis, 711 HPW/RHXM
Moderator

Dr. Rebecca Goolsby
Program Officer, Office of Naval Research

Eric Wallace
Chief, Concepts & Requirements, Joint Information Operations Warfare Center/Enterprise Operations Division

3:00 – 3:15 pm

REFRESHMENT BREAK

MILLER/VON STERNBERG FOYER

3:15 – 4:45 pm

ROUNDTABLE DISCUSSIONS

SINGLETON/MILLER BALLROOM

Protection, Sustainment and Warfighter Performance (PS&WP)

Human Systems Metrics (HSM)

Personalized Assessment, Education & Training (PAE&T)

Systems Interface and Cognitive Processing (SI&CP)

Human Information, Interpretation and Influence (HI3)

4:45 – 5:00 pm

CLOSING REMARKS

SINGLETON/MILLER BALLROOM

Dr. Jared Freeman
Human Systems Division Chair
Chief Scientist, Aptima, Inc.

5:00 pm

CONFERENCE ADJOURNS

The NDIA has a policy of strict compliance with federal and state antitrust laws. The antitrust laws prohibit competitors from engaging in actions that could result in an unreasonable restraint of trade. Consequently, NDIA members must avoid discussing certain topics when they are together at formal association membership, board, committee, and other meetings and in informal contacts with other industry members: prices, fees, rates, profit margins, or other terms or conditions of sale (including allowances, credit terms, and warranties); allocation of markets or customers or division of territories; or refusals to deal with or boycotts of suppliers, customers or other third parties, or topics that may lead participants not to deal with a particular supplier, customer or third party.

BIOGRAPHIES

DR. BRIAN PIERCE

Office Director, Information Innovation Office
Defense Advanced Research Projects Agency (DARPA)

Dr. Brian Pierce joined DARPA in 2014 and serves as the director of the DARPA Information Innovation Office (I2O).

Dr. Pierce has 30 years of experience developing advanced technologies in the aerospace/defense industry. Prior to joining DARPA, he was a technical director in Space and Airborne Systems at the Raytheon Company. During his first tour at DARPA, he served as the deputy office director of the Strategic Technology Office from 2005 to 2010. From 2002 to 2005, he was executive director of the Electronics Division at Rockwell Scientific Company in Thousand Oaks, California. From 1983 to 2002, he held various engineering positions at Hughes Aircraft Company and Raytheon in southern California.

Dr. Pierce earned a Doctor of Philosophy degree in chemistry, a Master of Science degree in chemistry and a Bachelor of Science degree in chemistry and mathematics from the University of California at Riverside. He has more than 20 U.S. patents.

DR. PAUL ZABLOCKY

Division Director, Complex Hybrid Warfare Sciences Division, Expeditionary Maneuver Warfare and Combating Terrorism Science and Technology Department
Office of Naval Research

Dr. Paul G. Zablocky currently serves at the office of Naval Research (ONR) as the Division Director of the Complex Hybrid Warfare Sciences Division (Code 301) within the Expeditionary Maneuver Warfare and Combating Terrorism Science and Technology Department. He is responsible for leading and directing an integrated portfolio of basic research, applied research, and advance technology development science and technology (S&T) efforts in support of the United States Marine Corps (USMC) and Naval Special Warfare.

Dr. Zablocky served as the Director of the US Army Communications Electronics Research Development and Engineering Center (CERDEC) Intelligence and Information Warfare Directorate (I2WD) from April 2015 to April 2016 and as the Director of Space and Terrestrial Communications Directorate (S&TCD) from June 2013 to April 2015. In both organizations he provided leadership and guidance to approximately 800 government civilians and contractors who executed S&T programs, developed prototypes, and provided systems engineering support for Army programs in the areas of communications, Electronic Warfare (EW), and intelligence. Prior to that Dr. Zablocky served as the Senior Research Scientist for EW Technology (ST) at CERDEC I2WD where he was responsible for developing, planning, coordinating, and executing the Army's EW S&T portfolio. Paul started his government career in 2005 designing and developing prototype EW systems that transitioned to Army Programs of Record. He has over 30 years of research and development experience in Electrical Engineering working in both defense and commercial industries. He served in the Navy from 1985 to 1989 achieving the rank of Lieutenant.

Dr. Zablocky received a Professional Master of Business Administration from the University of Massachusetts, a Doctor of Philosophy Electrical Engineering from the University of Pennsylvania, a Master of Science Electrical Engineering from the University of Central Florida and Bachelors of Science in Electrical Engineering and Physics from Fairleigh Dickinson University.

He is married to Barbara. Their daughter, Amanda, graduated from the Naval Academy and is now a pilot in Helicopter Sea Combat Squadron Eight assigned to the USS Nimitz. Their son, Daniel, is a recent graduate of The United States Military Academy and is in the Army Basic Officer Leader Course at Fort Benning, GA.

POSTER & DEMONSTRATION SESSION

Mixed Reality Environment for the Study of Human-UAV Interaction

Dr. Zhuming Ai
Naval Research Lab

Dynamic Robot Operator Interface (DROID) Assessment, Guidance, and Engineering Tool (AGENT)

Lisa Baraniceki
AnthroTronix, Inc.

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Doron Becker
Department of Homeland Security

Marianne Paulsen
Department of Homeland Security

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Massachusetts Institute of Technology

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Electric Boat Corporation

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U.S. Army Research Laboratory

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Natick Soldier Research Development & Engineering Center

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Aptima, Inc.

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U.S. Army Research Laboratory

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AnthroTronix, Inc.

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Rockwell Collins Simulation & Training Solutions

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Allen Dukes
711 HPW/RHCPA

Confined Spaces Monitoring System

Kevin Durkee
Aptima, Inc.

Wearable Tactile Display for Hands-Free Covert Communications with Semi-Autonomous Systems

Dr. Linda Elliott
U.S. Army Research Laboratory

Topside - Unmanned System Command and Control for Mission Planning, Piloting, and Analysis

Thomas Fulton
Naval Undersea Warfare Center Division Newport

Robust Personalization of Training and Assessment through the Generalized Intelligent Framework for Tutoring (GIFT)

Dr. Benjamin Goldberg
U.S. Army Research Laboratory, HRED

Characterizing Tactical Decisions through Exploratory Multivariate Analysis

Dr. Chris Hale
Georgia Tech Research Institute

Analyzing Expert Marksmanship from the Human Centered Perspective

Dr. Leif Hasselquist
Natick Soldier Research Development & Engineering Center

Using Artificially Intelligent Computer Based Training for more Sophisticated Learning Needs

Cenetra Johnson
The George Washington University

Laser Eye Protection: Balancing Protection and Performance

Dr. Julie Lovell
711th HPW / Bioeffects Division, Optical Radiation Branch

Ambient Activity Monitors (AAMs) to Display Hidden Computer System Information

Dr. Jamie Lukos
SPAWAR Systems Center Pacific

Training a Traditional High Risk Organization in Resilience Engineering

Dr. Christopher Nemeth
Applied Research Associates, Inc.

Personnel Optimization for Human-Machine Teaming in the Maritime Domain

LCDR Jacob Norris, USN
SPAWAR Systems Center Pacific

Intelligent Humans Systems Integration – Could we have helped prevent the McCain and Fitzgerald Collisions at sea?

Dr. Nandakumar Ramanujam
ASSETT, Inc.

Enhancing Mission Performance: Design Heuristics for Augmented Reality

Kimberly Ryan
The Charles Stark Draper Laboratory, Inc.

Using Work Models to Derive Assessment Measures for Cyber Protection Teams

Dr. Stoney Trent
U.S. Army War College

Measuring Coordination in Multi-Agent Reinforcement Learning

Michael Walton
SPAWAR Systems Center Pacific

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- Tactical Air Combat Maneuver Instrumentation systems
- Live and virtual, augmented and mixed reality training applications

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DCS is an employee-owned engineering firm with 40 years of experience serving DoD communities. The company's 1100 employees provide innovative solutions throughout all stages of DoD technology maturation and life cycle management. DCS has an extensive array of experience and capability in human systems integration and associated research. This includes leadership of the Cognition and Neuroergonomics Collaborative Technology Alliance (CaN CTA), a US Army funded international partnership of academic, industry and government collaborators conducting advanced neuroscience research. DCS also conducts research and development of human systems interfaces for US Army, Air Force and Navy including research in human autonomy teaming.

NOTES

MARK YOUR CALENDAR!

ARMY SCIENCE & TECHNOLOGY
SYMPOSIUM AND SHOWCASE

Emerging technologies for the future force

August 21–23, 2018

Washington Convention Center, Washington DC

NDIA.org/Army-Science

MARK YOUR CALENDAR!

2018 GROUND ROBOTICS CAPABILITIES CONFERENCE & EXHIBITION

April 10 – 11, 2018

Waterford at Springfield, Springfield, VA

NDIA.org/Robotics

Seeing into the black box:

Using eye tracking in user-driven workflows to better understand decision-making processes

Kristin M. Divis (kmdivis@sandia.gov | 505.284.6561)

Max G. Chen, Laura A. McNamara, & J. Dan Morrow

Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY

NNSA

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SAND 18-771612

Information Foraging Theory

- Human ‘informavores’
- Valuable information isn’t distributed evenly
- We look for *proximal semantic cues* to navigate to patches of interest
- Effective foraging strategies *maximize the value of information gained* relative to *effort finding the information*

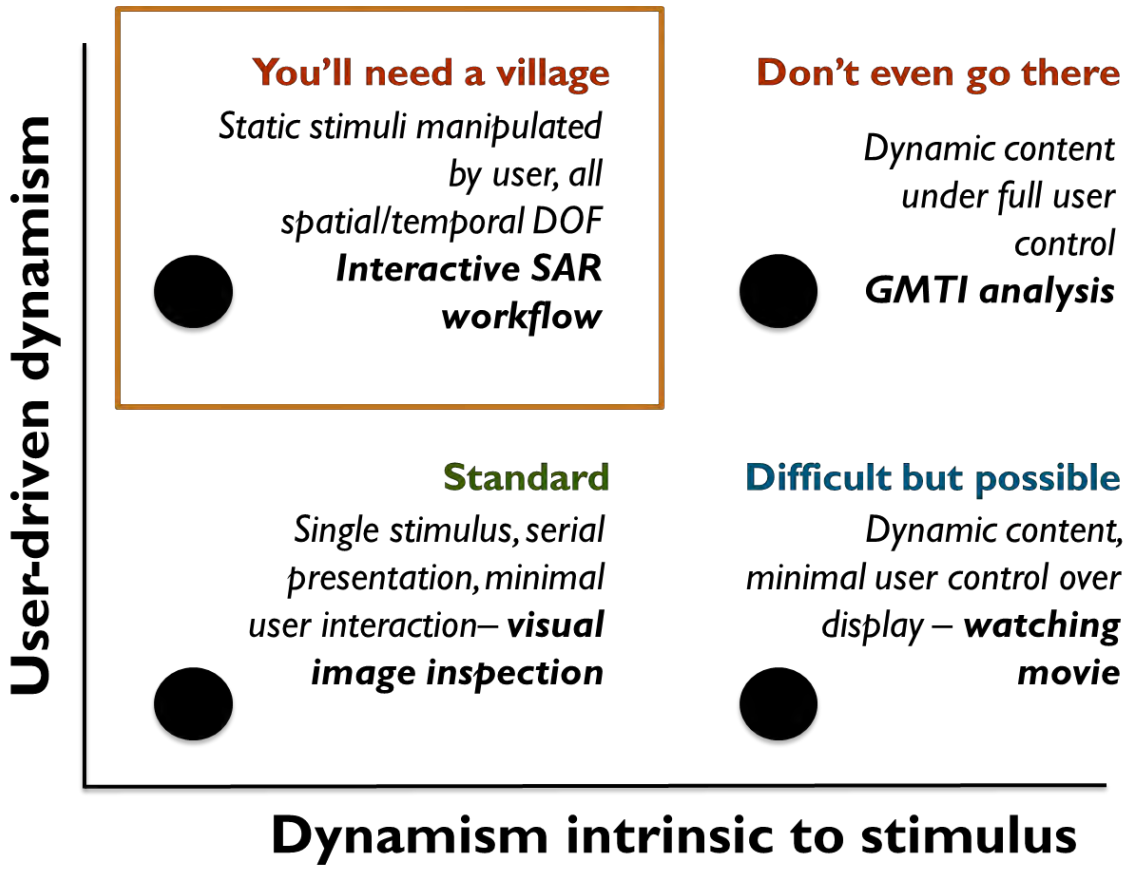
(see Pirolli & Card, 1999)

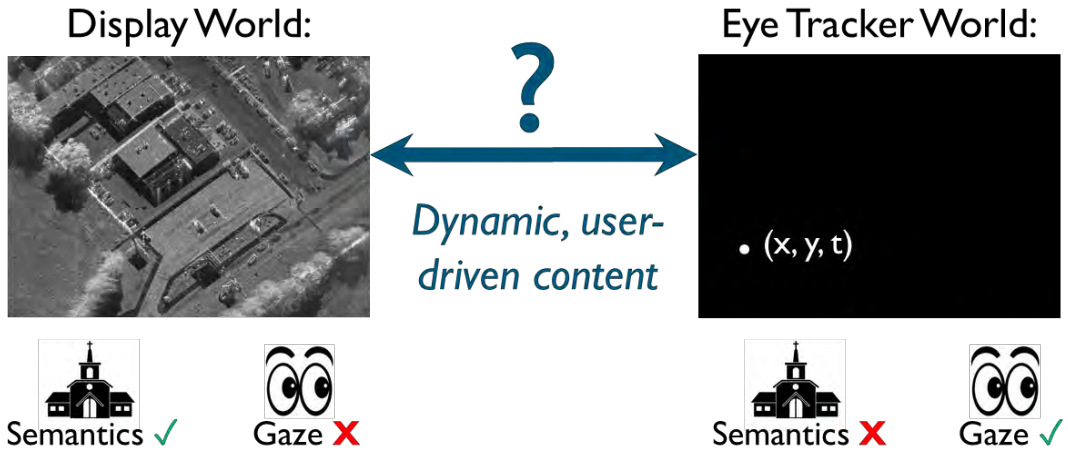
…so we "just" need to capture markers of analysts' search behavior?

- Design a simple signature detection task, invite SAR Imagery Analysts to find the targets (capturing interaction logs)
- Need to know *where* in an image the analyst looks (**gaze-contingent decision patterns**)

Great idea … but eye trackers couldn't support the workflows we wanted to study

The underlying problem:





What do we need?

Ingredients for a Simple Gaze-Informed Foraging Model:

Dynamically changing content →

Gaze tracked against display surface →

User operations (mouse, keyboard) →

Application/content log files →

VECTOR OF EVENTS

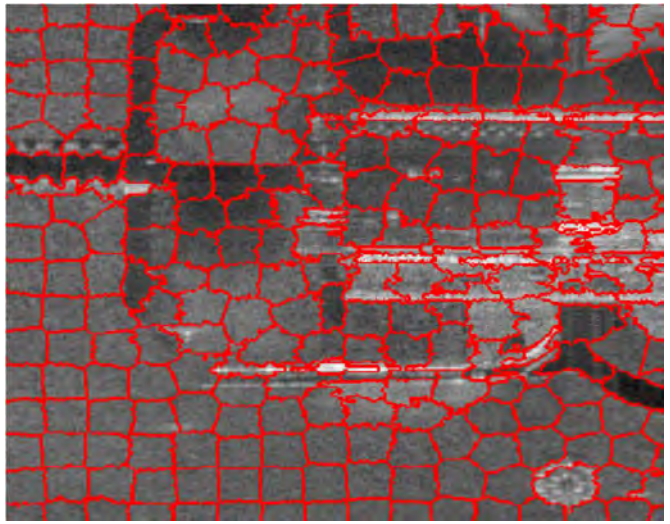
integrated into a single timeline with minimal latency

Step 1: Data "Sandbox" Creation

Synthetic Aperture Radar (SAR) images with rich metadata

- Each pixel tagged with info such as geospatial location
- Superpixel and megapixel algorithms established

4 constrained visual search task (zoomed in; click and drag to pan) to establish ground truth



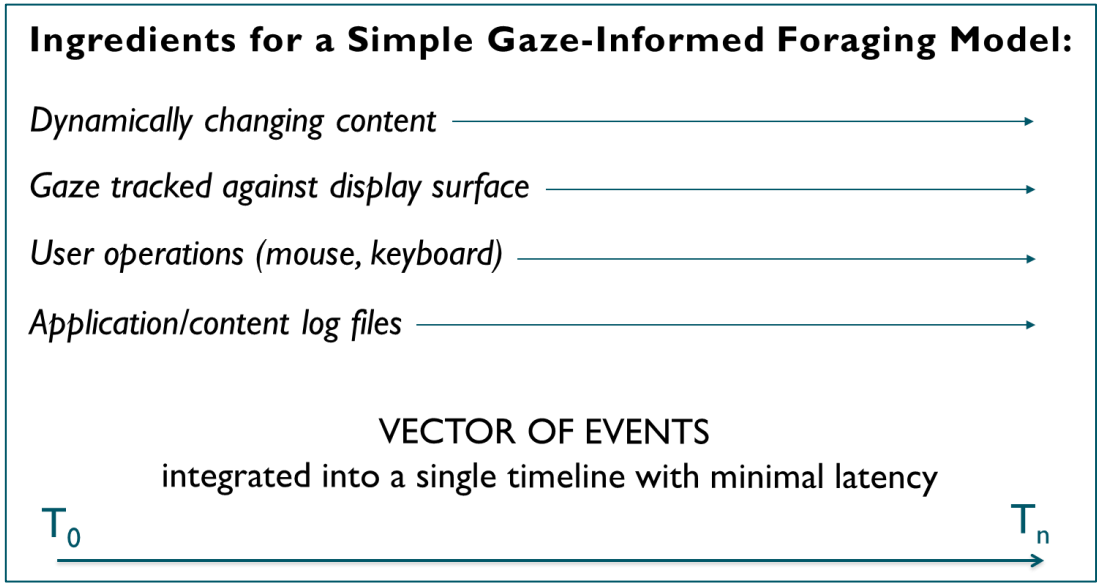
Superpixel Example
(Moya et al., 2014)

Step 2: Sequence of Events

Map data streams into a **sequence** of events.

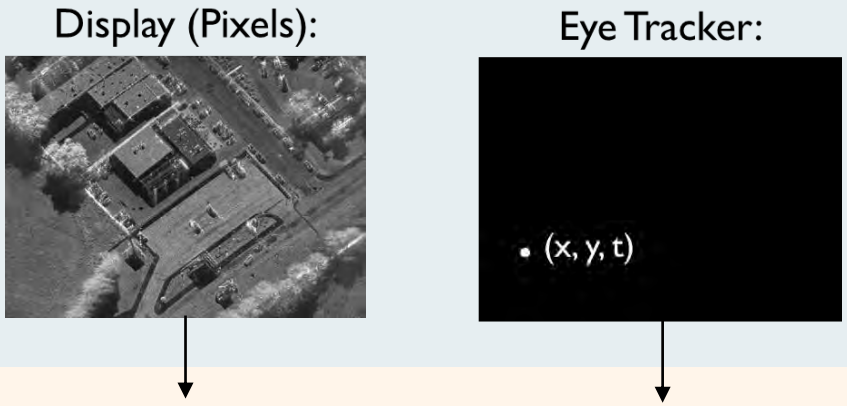
Requires:

- Integration of data streams
- Dimensionality reduction
- Temporal merging of data streams into a single sequence



Gaze data: Integration and dimensionality reduction

Starting place:

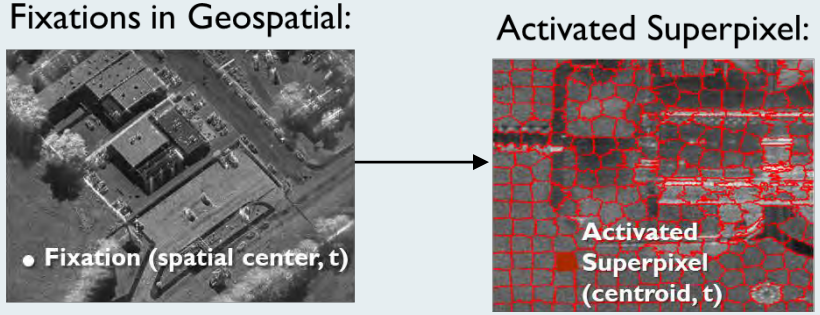


- Raw eye movement data (x,y,t) at every sample (60 Hz) in screen space
- Image coordinates of upper left of display

Simple transformations:

- Transform image coordinates to underlying geospatial coordinates (encoded in each pixel of SAR image)
- Transform raw eye movement data in screen space to eye movement data in geospatial coordinates

Dimensionality Reduction:

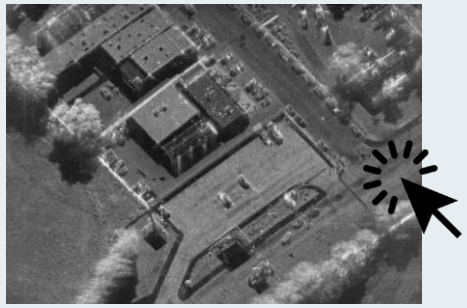


- Move from raw eye movement data to characterized gaze patterns (i.e., fixations)
- Move from fixations in geospatial coordinates to gaze-contingent activated superpixels

Log files: Integration and dimensionality reduction

Two additional data streams of interest: **mouse (panning behavior)** and keyboard* ("ground truth")

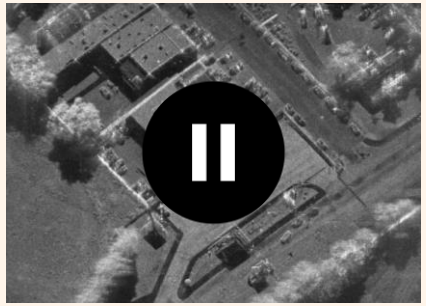
Raw data:



Coordinates of upper left corner of screen as participant pans (click + drag) to explore zoomed image

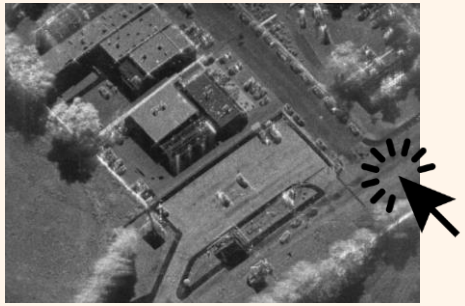
Discretize into runs & pauses:

Pause (not moving):



- Short (<1500 ms)
- Long (>1500 ms)

Run (moving):



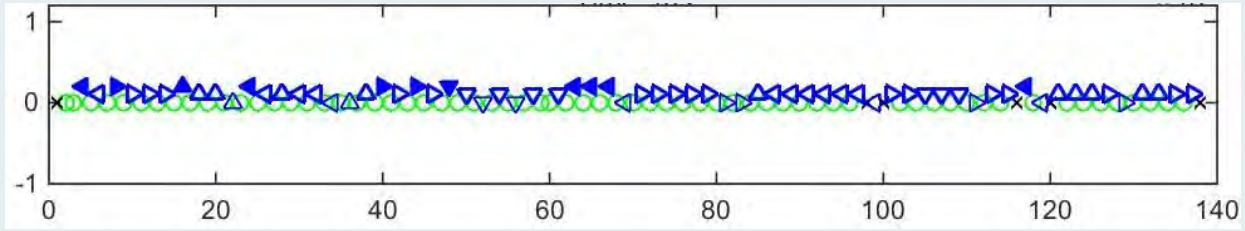
- Magnitude: Total distance (3)
- Angle: angle from start to end (4)
- Length ratio: Linearity or "curviness" (3)*

…and now we have **two critical data streams reduced in dimensionality** to a manageable space!

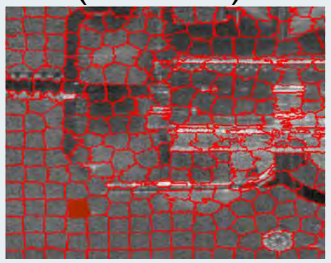
Merge data streams into single sequence

Discretized panning & gaze data:

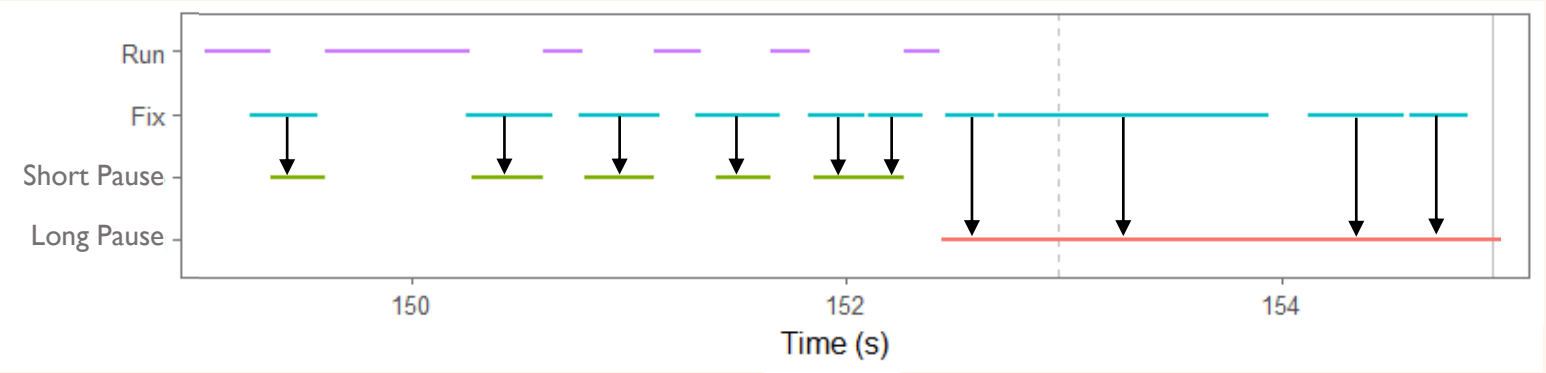
Runs (magnitude, angle, length ratio), short pauses, long pauses)



Activated superpixels (fixations)



Temporal alignment of panning & gaze data:



Merge into single sequence of tokens (0-255), replacing pauses with fixations:

67 - 7 - 53 - 136 - 1 - 42 - 1 - 188 - 7 - 78 - 203 - 91 - 116 - 1 - 26 - 8

Step 3: Analyze sequences

… we now have two critical data streams **reduced in dimensionality** and **integrated into a single sequence** of events!

- Treat sequences as a **vocabulary** of analyst interactions (e.g., text analytics, n-grams)
- Identify decision-making patterns and cues to interactions of interest (e.g., found a target or will find a target soon)
  - Markers of "good" or "bad" performance
  - Characterize individual analyst patterns of behavior
  - Characterize behavior associated with a particular task, regardless of analyst

Now what?

Refine, expand, and validate/verify our process

- End-to-end thinline prototype
- Narrow in on best features to include (e.g., better ways to discretize the data streams?)
- Move all the way to *meaningful*, *semantic* content
  - We've made it to superpixels, but what about "that's a car"?
  - Algorithms developed at Sandia can help with this
- Formally pull in ground truth data
- Validate and verify on new data set
  - Initial analyses focused on Task 1 (still have all of Tasks 2-4)
  - Collect additional data (same tasks, new tasks, expert population, beyond SAR, etc.)

Questions?

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Human Systems Community of Interest Government Panel

Human Systems Community of Interest Active Membership

STEERING GROUP

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Dr. Bindu Nair (OSD)
Mr. John Lockett (Acting) (Army)
Dr. Kevin Geiss (AF)
Dr. Michelle Sams (Army)
Mr. Doug Tamilio (Army)
Dr. Patrick Mason (Navy)
Ms. Lisa Sanders (SOCOM)

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Dr. Kelvin Oie (Army)
LCDR Pete Walker (Navy)
Ms. Cheryl Stewardson (Army)
Ms. Josephine Wojciechowski (Army)
Dr. Ben Petro (OSD)

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Mr. Rodney Long (Army)
Dr. Kendy Vierling (USMC)
Dr. Ray Perez (Navy)
CAPT Sidney Fooshee (OSD)
Dr. Sae Schatz (ADL)
Dr. Marty Bink (Army)

Protection, Sustainment, and Warfighter Performance
Dr. Mike LaFiandra (Army)
Dr. John Ramsay (Army)
Dr. Peter Squire (Navy)
Ms. Stephanie Miller (AF)
Dr. Lloyd Tripp (AF)
Dr. John Schlager (AF)
Ms. Roxanne Constable (AF)
Dr. Karl Van Orden (Navy)

Systems Interfaces and Cognitive Processes
Dr. Todd Nelson (AF)
Dr. Susan Hill (Army)
Dr. Micah Clark (Navy)
Dr. Mark Derriso (AF)
Dr. Erica Johnson (AF)
Dr. Caroline Mahoney (Army)
Dr. Jennifer Serres (AF)
Mr. Ed Davis
Dr. Tom McKenna

SICP (cont'd)
Dr. Liz Bowman (Army)
Dr. David Scribner (Army)
Dr. Rebecca Goolsby (Navy)
Mr. Eric Hansen (AF)
Dr. Edward Palazzolo (Army)
Dr. Lisa Troyer (Army)
Dr. Laurie Fenstermacher (AF)
Dr. Adam Russell (DARPA)

Human Systems Community of Interest Vision and Goals

Vision:

Develop and deliver new human-centered technologies to quantify mission effectiveness and to select, train, design, protect, and operate for measurably improved mission effectiveness.

Goals – to enhance mission effectiveness

- **Integrated simulations for mission training and experimentation**
- **Human-machine designs for mission effectiveness**
- **Assessment of (candidate) operator effectiveness**
- **Operating through battlespace stresses**
- **Mastering the PMESII* battle space**

**Political, Military, Economic, Social, Infrastructure, & Information*

State of Technology: Focus Areas*

** Note: Slide as example only*

Personalized Assessment, Education, and Training

Right Person, Right Job, Right Skills

- First Principles for Training Design
- Personnel Selection and Assignment

Protection, Sustainment, and Warfighter Performance

Ensuring Warfighter Safety and Survivability

- Understanding and Quantifying the Effects of Critical Stressors
- Critical Stressor Mitigation Strategies

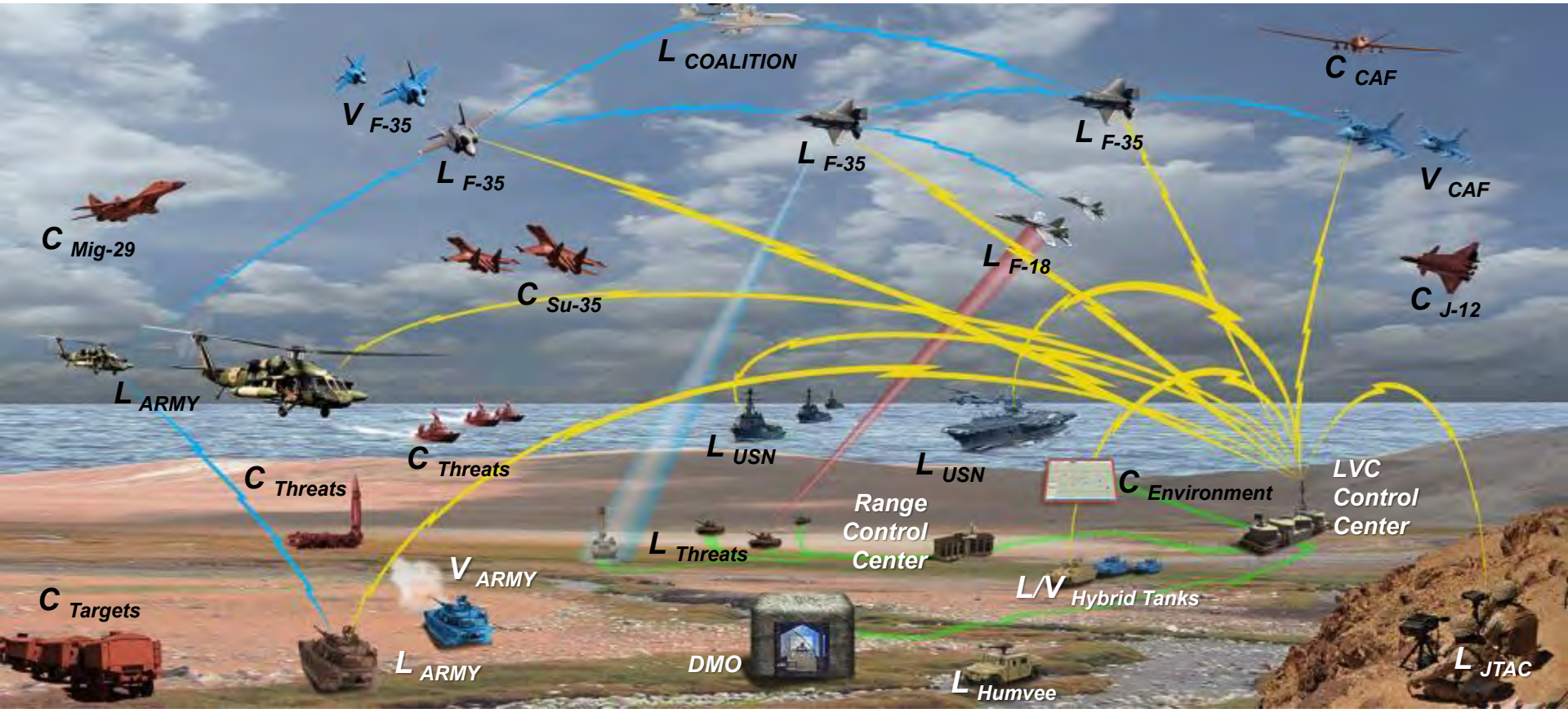
System Interfaces and Cognitive Processes

Effective, Natural Human-Machine Teaming

- Human-Machine Teaming
- Intelligent, Adaptive Aiding
- Human Information Interpretation & Influence

Operational Concept
Mission Effectiveness Quantification

Capability: Integrated, persistent Live-Virtual-Constructive (LVC) training environments incorporating adaptive training methods to accelerate Service, Joint, and Coalition Readiness



Affordable Mission Realism – Integrated Forces – Quantified Effectiveness

Human-Machine Teaming Collaboration; Combat Teaming

Human Systems COI S&T Focus Areas that Address Human-Machine Teaming

1. **Learning Machines**
   - Computational Models of Human Cognitive, Psychomotor, and Perceptual Capabilities
2. **Human-Machine Collaboration**
   - Intuitive, Multi-sensory, Adaptive Interfaces
   - Natural Language Interfaces
3. **Assisted Human Operations**
   - Intelligent, Adaptive Aiding
4. **Human-Machine Combat Teaming**
   - Trust Calibration and Transparency of System Autonomy
   - Metrics of Mission Effectiveness at Individual and Unit Level
5. **Autonomous Weapons**
   - Systems that can take action, when needed
   - Architectures for Autonomous Agents and Synthetic Teammates

… and Experiments Using Realistic Mission Scenarios

Service Demand Signals

Personalized Assessment, Education and Training

- Personalized, integrated assessments and training to improve performance, accelerate proficiency and increase affordability
- Enhanced warfighter performance through scenario based training & automated performance based readiness assessments
- Maintain air superiority over complex, evolving threats using adaptive training

Protection, Sustainment and Warfighter Performance

- Greater force protection to ensure survivability across all operations and environments
- Maintain health & injury recovery; reduce noise induced hearing loss
- Agile Combat Support through countering aerospace physiology and toxicology threats, reducing cognitive workload

System Interfaces and Cognitive Processing

- Achieve operational maneuverability through soldier-system integration
- Design systems to enable effective human machine interaction, including robotics & autonomous systems
- Enhanced interaction & trust w/ autonomous systems; increased SA for operators; reduced analyst workload
- Provide situational awareness; timely mission command and tactical intelligence human-agent teaming

- *Army Enduring Challenges*
- *Navy Vision/Objectives*
- *AF Core Mission/Challenges*

COI-to-COI Collaborations

- **ASBREM**
  - Human Performance Optimization Committee
  - Joint Biomedical Modeling and Simulation Initiative
  - Walter Reed Army Institute of Research (WRAIR) evaluating TAPAS as a contributor toward predictors of mental health & medical attrition
- **ASBREM, Sensors, CWMD**
  - Wearable Physiological Monitors
- **Autonomy**
  - Roadmap development: Human-Machine Teaming shared area
  - V&V Licensing Study
  - Executing Joint-Service Autonomy Research Pilot Initiatives
- **Cyber**
  - Cyber Selection and Training
  - Cyber Situational Awareness
- **CWMD**
  - Dark web concerns, social network analysis, and counter-terrorism research

COI Activity 2017

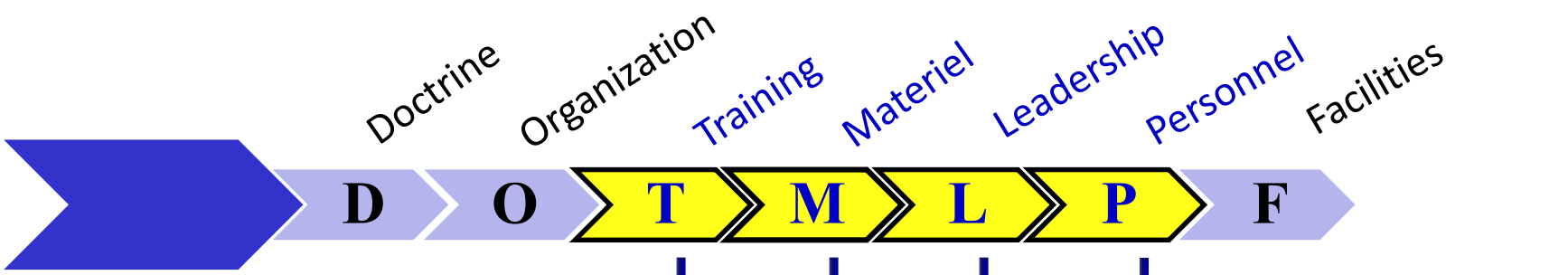
Major Accomplishments

- IMPACT DoD Virtual Lab allowed one operator controls 12 vehicles – force multiplier, lauded by OSD as Autonomy Re-search Pilot Initiative (ARPI) poster child
- Advanced technologies for Battlefield Airman (BATMAN) resulted in 30 tech transitions to Special Tactics operators in advanced audio/visual communications and lightweight equipment, mission rehearsal, and multi-patient monitoring. Transitioning Battlefield Airmen Trauma Distributed Observation Kit capability to Army and joint medical community.
- Augmented Immersive Team Training (AITT) provided a unique JTAC training capability for Joint Staff exercises. Scheduled to transition to multiple Marine Corps programs.
- Multiple Live Virtual Constructive (LVC) product transitions; Deployable LVC baseline, Learning Management SOA Advanced Technology Demonstration completed
- Generalized Intelligent Framework for Training transitioned to 900 users in 53 countries
- DoD Wearables Technology Workshop Feb 2017

Engagements with organizations, individuals, entities outside DoD

- 2017 NDIA HS Conference well attended
- 2017 IR&D event 20-23 June , 3rd Biennial (27 Companies participated)
- HS COI sub area meetings at I/ITSEC
- Digital and Social Media Assessment course at National Defense University with NATO attendees
- Ongoing Metrics White paper discussions Between PAET & Industry
- 2017 All Hands COI meeting, NASA, DOE, DHS presented
- Aerospace Medical Association Annual Meeting April 2017

Impact of Human Systems Community of Interest



$450M COI Budget Has Broad Impact in Several DOTMLPF Areas

SUB-AREA S&T THRUSTS

Personalized Assessment, Education, and Training

PAET Scope
Personalized Assessment, Education & Training (PAE&T)

Research and development in personnel assessment will produce integrated measures and adaptive testing for more precise assessment of individual potential, yielding improved personnel selection and assignment. Meanwhile, work in education and training will produce competency-based systems grounded in quantitative metrics to enable personalized, proficiency-based training to accelerate acquisition and enhance operational performance. The end result is more capable warfighters with decreased training costs.

Thrust Area 1:

Training, Education, and Personnel Development

S&T Focus Areas on Roadmap:

- Realistic, secure, and adaptive LVC environments
- Persistent **and** personalized readiness assessment and tracking
- Multi-Level modeling for readiness management
- Computational cognitive science research to support model and agent development for training and operational support

Thrust Area 2:

Personnel Selection and Assignment

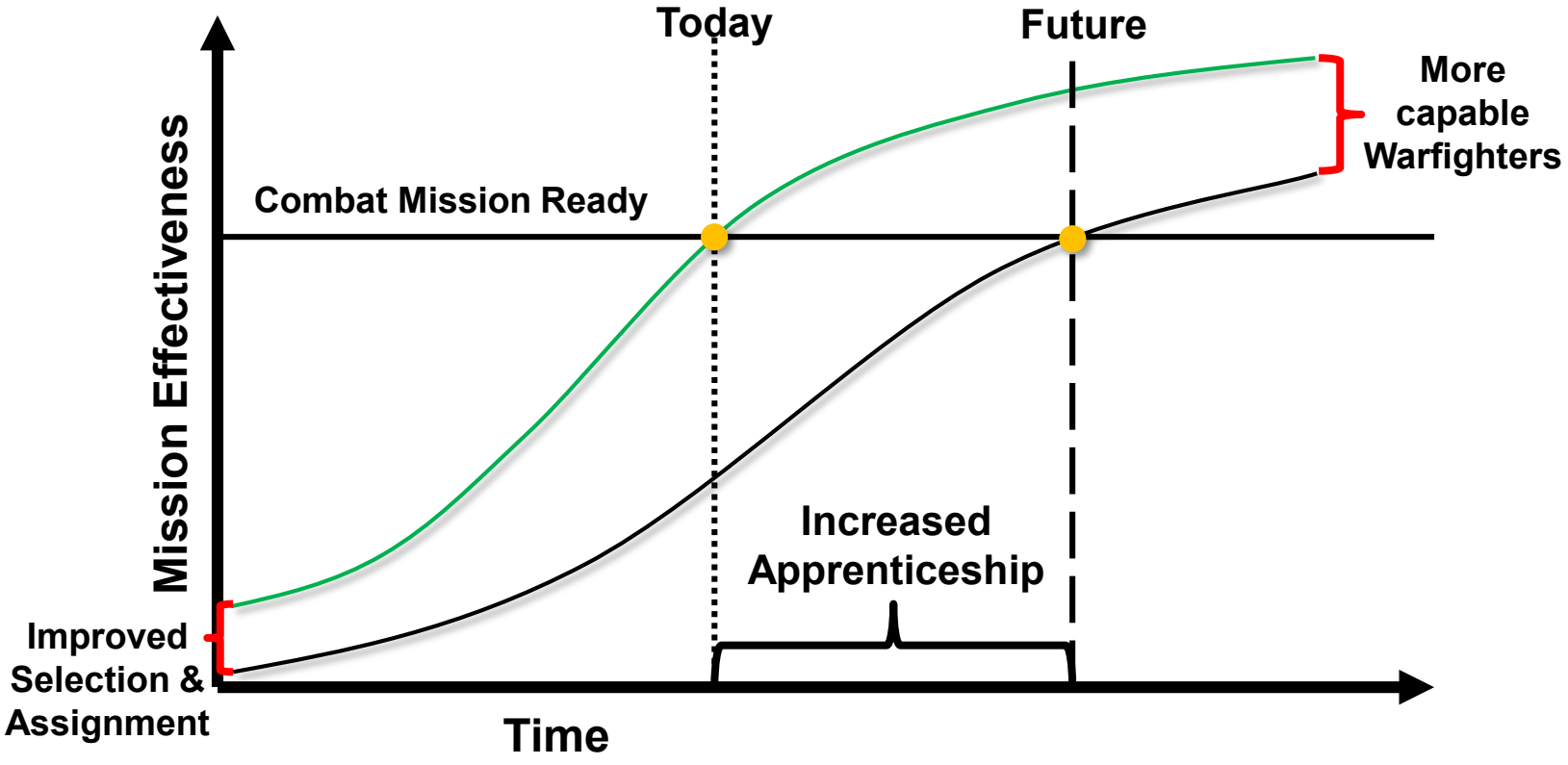
S&T Focus Areas on Roadmap:

- Predictors: Expand/refine non-cognitive measures (e.g., Tailored Adaptive Personality Assessment System)
- Outcomes: Expand/refine behavior and performance data
- Models: Expand/refine predictive analytic model for integrated cognitive plus non-cognitive measures to predict attrition, performance, and behaviors

HUMAN SYSTEMS COI SUB-AREA:
Personalized Assessment, Education, and Training

VISION

A readiness ecosystem that ensures the right person has the knowledge, skills, and experiences needed to be mission ready for a dynamic and uncertain 21st century operating environment



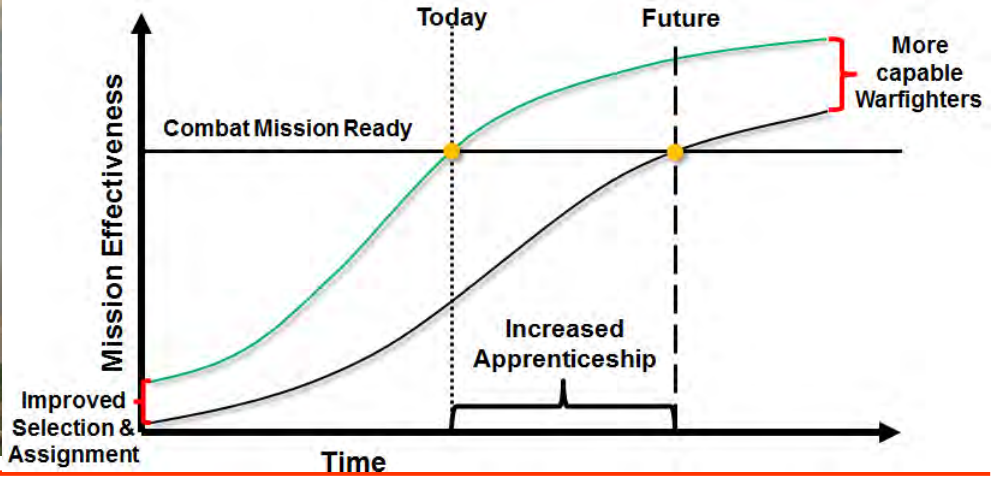
Our Story

• Challenges

- More unpredictable and asymmetric adversaries
- Dynamically evolving operational environments
- One solution does not meet all
- Reduced manning
- Diverse personnel pool
- Budget & manpower constraints
- Better training at point of need

• S&T Solutions

- Adaptive LVC environments that keep pace with operations
- Human Science models for assessment and training
- Performance measurement and assessment to tailor training
- Cognitively-based instruction, agents and training schedules
- Science of Learning



Thrust 1: Training, Education, and Personnel Development

Delivering the Mission

Education & Training Practices and Technologies that Support Efficient and Effective Development of Mission Readiness and Cognitive Agility

- Leverage learning sciences and technology to reduce resource costs (cost, manpower, time)
- Tailor training to individuals to enhance warfighter capabilities and agility
- Measure, track, & warehouse quantitative, proficiency-based performance measures

Delivering Capability (i.e., End States)

- Persistent, interoperable learning "ecosystem" …with personalized measurement; readiness tracking
- Secure LVC joint/coalition training environments …with realistic constructive teammates / adversaries
- Consistently high-quality training and education, tailored to individuals and available when needed
- Increased insight into personnel (data) informs individual learning decisions and mission planning

Key Technical Challenges

- Developing, deploying, and using proficiency-based performance measures / analyses
- Warehousing & using (big) learning data to inform life-long learning and operational decisions
- Securely integrating LVC environments
- Develop adaptive and valid cognitive agents
- Adapting learning sciences to military contexts and foster the right culture for their use

Example Program Successes

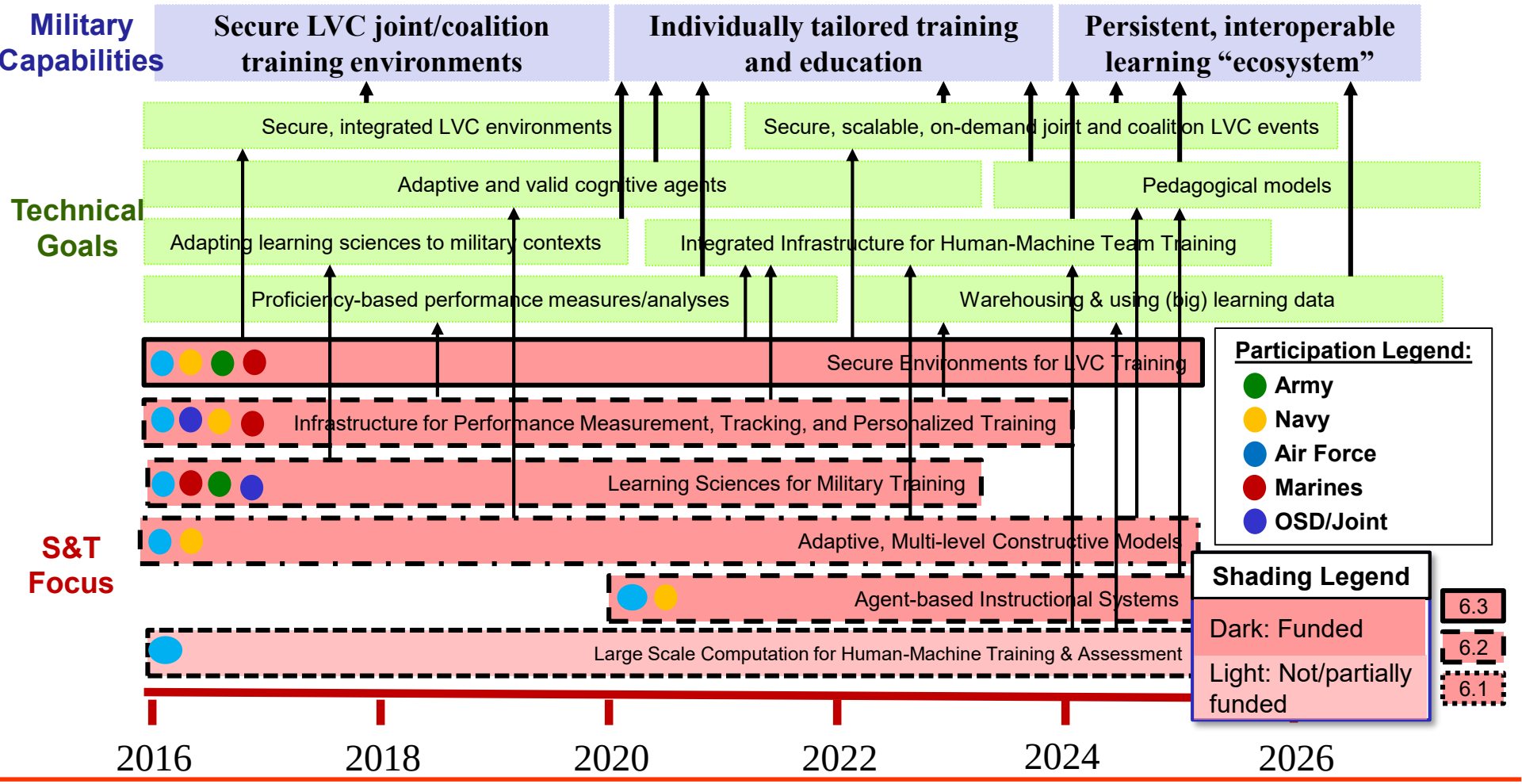
EXPERIENCE API

TXA AITT

Training, Education, and Personnel Development
Roadmap

Mission Need

Education & Training Practices and Technologies that Support Efficient and Effective Development of Mission Readiness and Cognitive Agility



Training, Education, and Personnel Development
Program Detail (1)

S&T Focus Areas	Near-term					Mid/ Far-term	Operational Opportunities
	FY 16	FY 17	FY 18	FY 19	FY 20		
Secure Environments for LVC Training *Develop, validate, and demonstrate seamlessly integrated Live, Virtual, and Constructive (LVC) components into persistent, secure, and manageable training and operations environments across the Range Of Military Operations (ROMO)*	Adaptive LVC Training for Enhanced Warfighter Readiness						Seamless integration of live, virtual, & constructive training environments; personalized training grounded in operationally relevant proficiency assessments; Range infrastructure to support LVC integration for 4th/5th gen aircraft; air-ground simulation integration, scalable, adaptive constructive agents that think and act like people to support training & ops
	Adaptive Training for C4ISR						
	Secure LVC Advance Training Environment.						
	EDUCAT2E (see notes)						
	Live Virtual Constructive Simulation & Training						
	Live, Virtual, Constructive Training Fidelity						
	Future Integrated Training Environment						
Infrastructure for Performance Measurement, Tracking, and Personalized Training *Quantitative, embedded performance measures in training and operational systems, combined with warehousing capabilities and metrics to assess mission readiness and effectiveness over a career*	Autonomous Models and Agents for Training & Operations						Formal, quantitative measures of proficiency; Embedded performance measures in training environments and operational systems; Integrated and persistent warehousing, diagnosis, and assessment of readiness to drive personalized training requirements and career-long readiness management
	Learning Continuum and Performance Aid						
	Adaptive LVC Training for Enhanced Warfighter Readiness						
	Adaptive Training Research						
	Total Learning Architecture						
	Complex Cognitive Skills						

Training, Education, and Personnel Development
Program Detail (2)

S&T Focus Areas	Near-term					Mid/ Far-term	Operational Opportunities
	FY 16	FY 17	FY 18	FY 19	FY 20		
Adaptive, Multi-level Constructive Models *More robust, valid, & Integrated mechanisms that enable constructive agents that truly think and act like people for training and operational applications; Incorporate robust capabilities for situation representation and language processing to support human-machine teaming.*	Adaptive LVC Training for Enhanced Warfighter Readiness						Realize the full potential of LVC to provide personalized, anytime, anywhere training. Reduce manpower costs for training with increased adaptivity in constructive forces. Enhanced validity; increased cognitive & behavioral fidelity; agents that are language enabled & situationally aware; consideration of cognitive moderators; emphasis on complex & uncertain operational contexts; also facilitates human-machine teaming
	Autonomous Models and Agents for Training & Operations						
	Computational/Cognitive Models for ITS						
	Live, Virtual, Constructive Training Fidelity						
Human-Machine Training & Assessment *We must prepare for the need to train autonomous systems for the same operational realities as humans, including training with human teammates; requires bridging among machine learning, large scale computing, and LVC.*	Autonomous Models and Agents for Training & Operations						Training to tailor baseline autonomous systems for specific capabilities, environments, and operations. Integration of large-scale computing resources with machine learning capabilities in LVC training environments will be a game changer in human-machine teaming by providing the opportunity for humans and machines to train separately and together in the same environments to prepare for the uncertainty of real operations.
	Adaptive LVC Training for Enhanced Warfighter Readiness						

Training, Education, and Personnel Development
Program Detail (3)

S&T Focus Areas	Near-term					Mid/ Far-term	Operational Opportunities
	FY 16	FY 17	FY 18	FY 19	FY 20		
Learning Sciences for Military Training *Adapt research on learning and training to the unique requirements of the military environment*	Adaptive LVC Training for Enhanced Warfighter Readiness Adaptive Training Research Total Learning Architecture Personal Assistant for Learning Accelerating the Development of Small Unit Decision-Makers						A significant scientific base exists in the learning sciences, but most of it has been developed in non-military contexts. Adapting and extending existing research for the unique requirements of military training will improve its efficiency and effectiveness

Technology Highlight: Predictive Performance Optimization (PPO)

American Heart Association. Laerdal helping save lives

AIR EDUCATION & TRAINING COMMAND | UNITED STATES AIR FORCE SCHOOL OF AEROSPACE MEDICINE | AIR MOBILITY COMMAND | U.S. AIR FORCE ACADEMY

Program

- Use quantitative models of human learning and forgetting to optimize and personalize training schedules

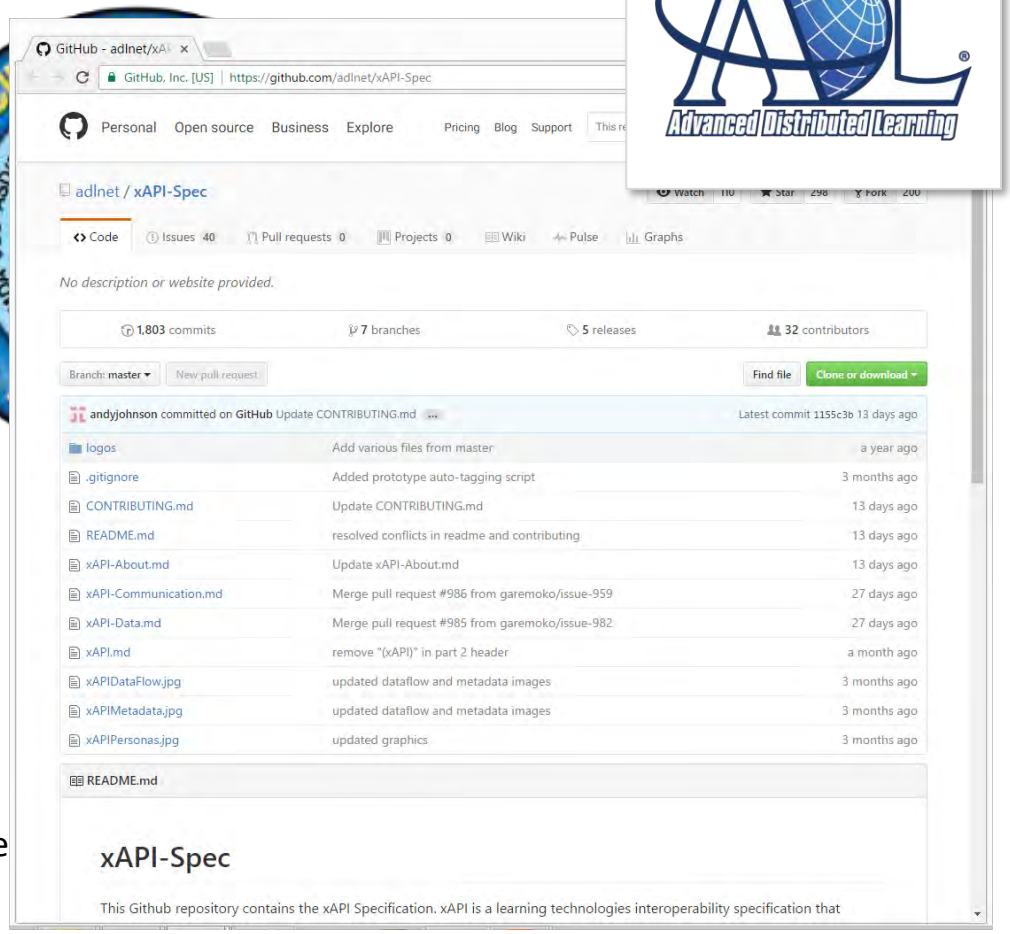
Status & Impact

- Improves training efficiency
  - Shifts from calendar-based training to cognitively principled personalization schedules
  - Minimizes training costs/time while maximizing performance effectiveness
- More effective acquisition of training objectives & more sustained proficiency
- Demonstrated to maximize performance effectiveness while simultaneously reducing time/costs in training

What? Developed by the Advanced Distributed Learning (ADL) Initiative, **Experience API (xAPI)** is a technical specification that facilitates the standardized documentation and interoperable communication of learning experiences (i.e., data) among disparate software systems. Essentially, it helps breakdown data stovepipes between education and training technologies.

Why? xAPI helps fuel learning analytics, not just within a single training system or course, but potentially across someone's entire lifelong learning set of experiences. Today, xAPI has been integrated into numerous COTS systems and demonstrated in various DoD/Federal settings. Even TechCrunch recently published an article about how xAPI-based data will soon replace the standard resume!

Who Cares? Using xAPI will allow multiple, disparate learning devices (e.g., e-learning, mobile learning, simulations, physical sensors) to be used longitudinally as a cohesive system. It enables broad human performance data management and interoperable exchange. Ultimately, this will enable much improved analysis of learning/performance, better informing lifelong instructional adaptation and planning, as well as talent management activities.



Technology Highlight: Secure LVC Advanced Training Environment (SLATE)

Live, Virtual, Constructive Operational Training Advanced Technology Demonstration Funded

- $47M demonstration of 4th and 5th generation LVC training
  - Aircraft software modifications
  - Waveform, Radio
  - Model and data processor
  - Multiple Independent Levels Encryption (MILS)
  - P5 Pod and F35 LRU form factor
  - Enhanced range infrastructure
  - Standards, data specifications, interface control docs
- Mission impact and effectiveness use cases

Success Story: Computer Generated Forces
Training Executive Agent (TXA)

Operational Challenge

"An integrated LVC training environment with today's battle complexity is essential to improving proficiency across all current and future mission sets." (Naval Aviation Vision 2016-2025)

Problem: High manpower to run complex virtual training

Objective: Make Computer Generated Forces (CGF) more intelligent and adaptive to training objectives

Outcome: Transitioned the Training Executive Agent (TXA) into the Navy's Next Generation Threat System

S&T Accomplishments

- TXA monitors a training exercise and issues "directives" to other CGFs to modify behaviors according to a higher level scenario director (training objectives)
- TXA used in NIFC-CA training scenarios
- Exploring TXA usage on aviation pods, thus providing unique flexible embedded training capabilities

Return on Investment

Affordability

- Aid instructors and "pucksteers" who dynamically controls CGF during execution of a training scenario.
- Reduce number of required "pucksteers", reduce overall training costs

Readiness

- Provide trainees with tactically realistic entities, in realistic complex battle scenarios
- Allow instructors to focus on trainee, not on playing roll in scenario

Thrust 2: Personnel Selection and Assignment

Delivering the Mission

- Initial Military Training attrition is ~10% ($1.7B cost/yr)
- IMT attrition could be reduced to ~ 8% (saving ~.34B/yr) if current S&T product (TAPAS) was implemented to assess personality. IMT attrition could be reduced to 6% (saving $.68B/yr) with FY22 S&T products.
- Reduce negative behaviors for enlisted by ~5%.
- Increase satisfaction, performance, and retention in critical specialties by ~15%.

Delivering Capability

Maintain our competitive edge in Human Capital (Force of Future).

- Reduce attrition and negative behaviors with more precise assessments of candidates for initial entry & job assignment.
- Improve performance and retention with an emphasis on critical specialties (e.g., cyber) through advancements in talent assessment.

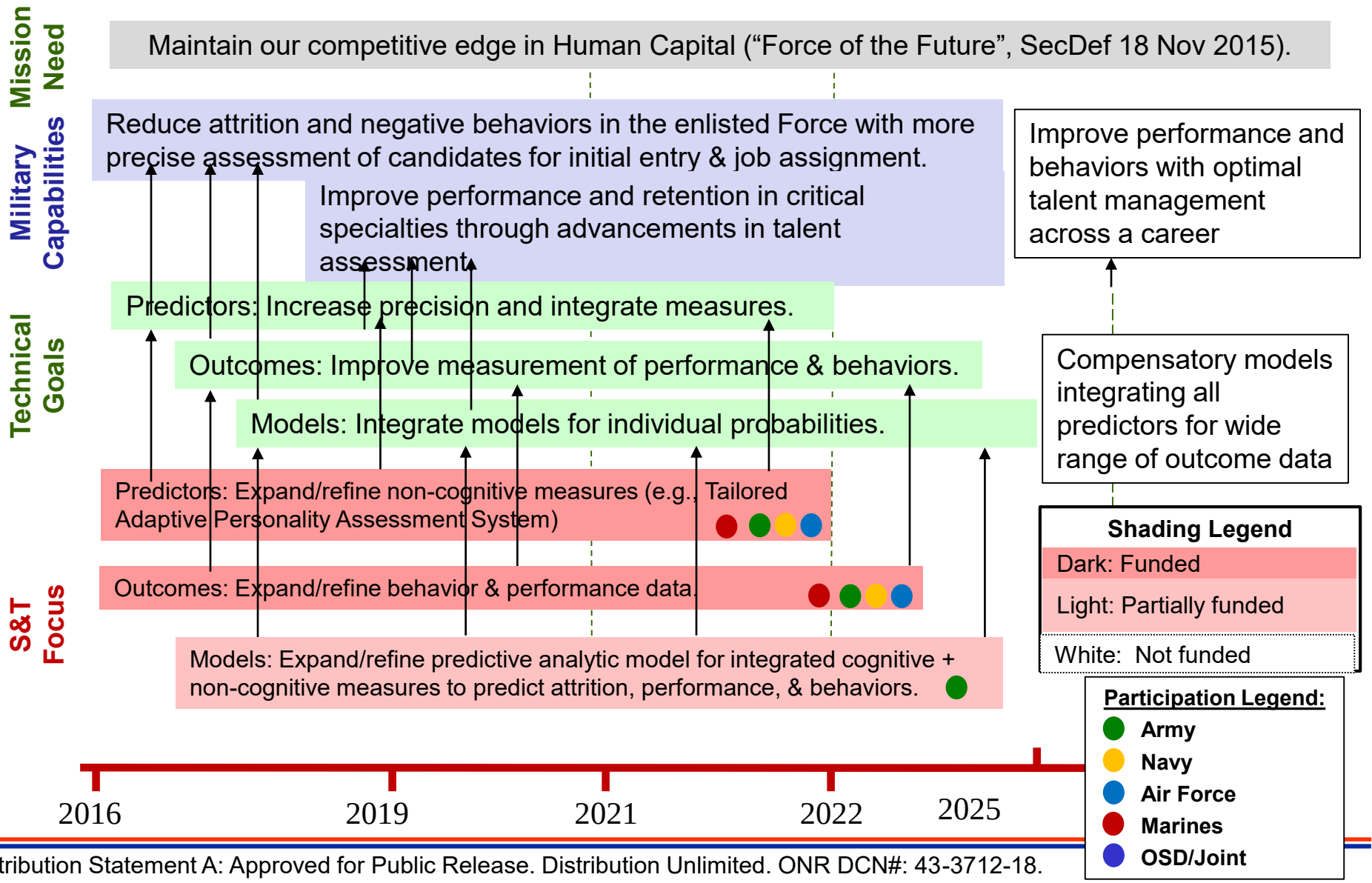
Key Technical Challenges

- Predictor measures: Existing measures lack individualized precision and are not integrated.
- Outcome measures: Performance and behaviors are difficult to measure and systematically obtain over a career.
- Predictive models: Existing models are stove-piped and based on group probabilities.

Example Program Success

- Enlisted Personnel Selection – TAPAS

Personnel Selection and Assignment



Personnel Selection and Assignment
Program Detail

S&T Focus Areas	Near-term					Mid/ Far-term	Operational Opportunities
	FY 15	FY 16	FY 17	FY 18	FY 19		
Predictors *Expand and refine non-cognitive measures (temperament, interests) and specialized cognitive assessments.*	Expand and increase precision of Tailored Adaptive Personality Assessment						More precisely and fully assess individual potential and risk.
	Develop, refine, and validate Vocational Interest Inventories						
	Develop and refine specialized selection tests (e.g., Cyber, UAS)						
	Personnel Measures Research						
	Selection for UAS Personnel (SUPer)						
Outcomes *Integrate the behavioral and competency data that define criterion job performance.*	*Leverage Training S&T competency assessments in realistic mission scenarios.*						More accurately assess performance and behaviors.
	Develop, refine, and validate behavioral outcome measures						
	Readiness and Resilience						
Models *Expand and refine predictive analytic models for integrated personnel measures to predict attrition, performance, & behaviors.*	Predictive analytical models based on predictors and longitudinal outcomes.						With enhanced Talent Management, improve performance, reduce attrition and negative behaviors.
	Human Science Models						

Success Story: Enlisted Personnel Selection

Tailored Adaptive Personality Assessment System

Operational Challenge

Increase precision of assessing individual potential, risk, and fit to a military career.

- 26 personality dimensions such as optimism, excitement seeking, and non-delinquency
- Applicant chooses from statement pairs generated on-the-fly based on responses

S&T Accomplishments

- State of the art personality assessment
- Developed in partnership with industry
- 2009: Limited operational screening (Army)
- 2010-2011: Administered to recruits (Navy)
- 2014: Began selection for 5 specialties (AF)
- 2015: Administered to recruits (Marines)

TAPAS

Which of these statements is most like you?

- I am not one to volunteer to be group leader, but would serve if asked.
- My life has had about an equal share of ups and downs.

(example statement pair)

Return on Investment*

Readiness

- Reduces attrition by 5%
- Reduces Initial Military Training re-starts by 3%
- Reduces conduct incidents by 5%

Affordability

(attrition cost – recruiting, training)

- Current implementation saves ~ $30M/year
- Expanded use can save ~ $50M/year

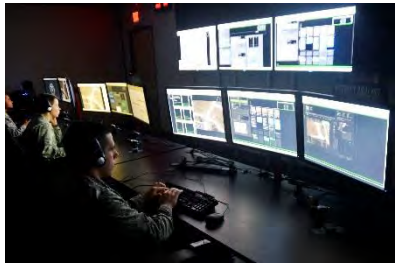
* Based on Army data for limited operational screening.

System Interfaces and Cognitive Processes

HUMAN SYSTEMS COI SUB-AREA:
System Interfaces & Cognitive Processes

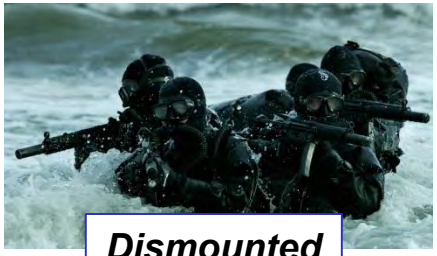
VISION

Warfighters teamed with machines through intuitive, personalized interfaces that enhance warfighters' mission effectiveness.



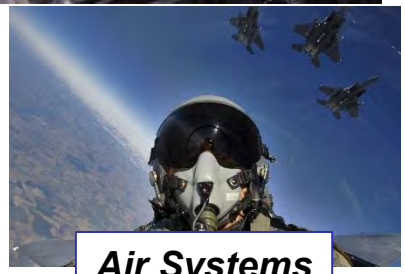
Information Systems Operators





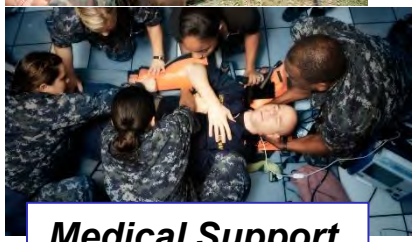
Dismounted Operators





Air Systems Operators





Medical Support Operators

Thrust 1: Human-Machine Teaming

Delivering the Mission

- Increased capability with smaller force structure across air, land, sea, space, and cyber
  - 1 MQ-9 Operator controlling 7 simulated MQ-9s
  - Reduced ISR PED Cell Operators from 5 to 3
  - Closed Loop Medical Technology Research
- USTRANSCOM Global Mission Scheduling System
  - Reduced logistics and personnel footprint ; reduced planned flying hours >2% saving $37M/yr
- Trusted synthetic teammates that provide recommendations for battlespace operations
  - Reduced manpower and training requirements
- Ability to operate safely in highly contested environments
  - Reduced exposure to personnel

Delivering Capability

Seamless human-machine interfaces enabling optimized weapon system and warfighter performance in all contested domains and mission environments:

- Demonstrate highly effective, agile human-machine teaming
- Create actively coordinated teams of multiple machines
- Ensure safe and effective systems in uncertain and dynamic environments

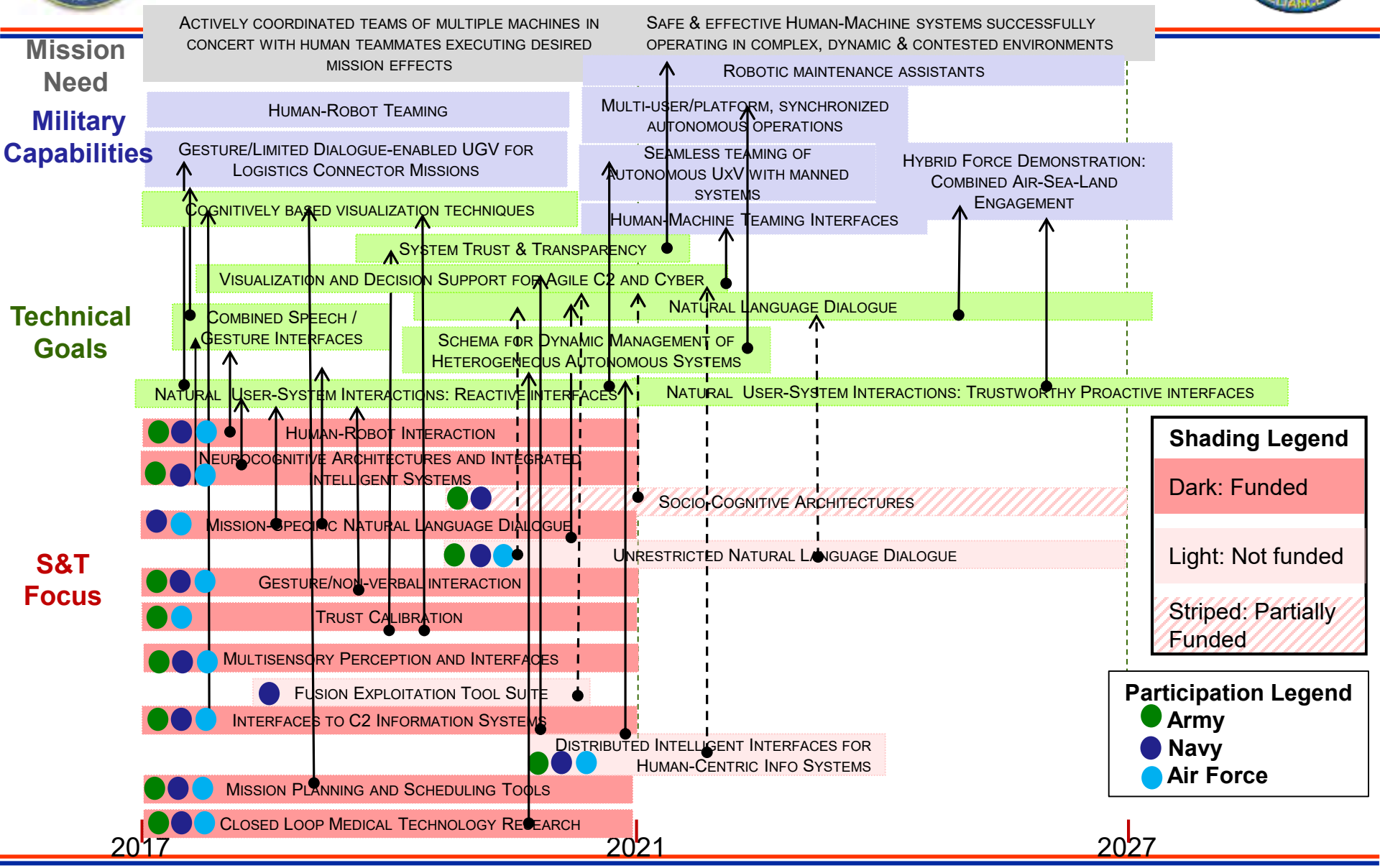
Key Technical Challenges

- Immature intuitive, multisensory, adaptive interfaces
- Lack of robust and reliable natural language interfaces
- Absence of effective gesture control interfaces
- Fragile cognitive models and architectures for autonomous agents and synthetic teammates
- Insufficient degree of trust calibration and transparency of system autonomy
- Immature decision support tools

Program Overview

- Human-Robot Interaction
- Multisensory Perception and Data Presentation Interfaces
- Supervisory Control Technology Integration and Demonstration

Human-Machine Teaming



Human-Machine Teaming
Program Detail

S&T Focus Area	Near-term					Mid/ Far-term	Operational Opportunities
	FY 15	FY 16	FY 17	FY 18	FY 19		
Mission Planning and Scheduling Tools	Visual Interactive Exploratory Data Analysis					Soldier-Centered Design Tools; Mission Planning and Scheduling Tools	Mission planning and scheduling tools that simplify COA generation and enhance mission efficiency.
Interfaces to C2 Information Systems	Supervisory Control Technology Integration and Demonstration					Soldier-Centered Design Tools; Interfaces to C2 Information Systems	Operator-centered interfaces to C2 Information Systems that enhance/multiply mission effectiveness.
Multisensory Perception and Interfaces	Multisensory Perception and Data Presentation Interfaces					Human-Robot Interaction; Advanced Technologies for Battlefield Airmen	Novel multi-modal human-system interfaces that enhance operator performance.
Neurocognitive Architectures and Integrated Intelligent Systems	ONR Computational Neuroscience					Brain-Computer Interaction; Human Insight and Trust	Neurocognitive architectures that maximize human-machine team performance.
Human-Robot Interaction	Human-Robot Interaction					Novel-Human-Intelligent Agent Interactions; Human Interaction with Adaptive Automation	Human-machine teams that can successfully operate in an agile fashion in an operational environment.
Closed Loop Medical Technology Research	Closed-Loop Oxygen Generation and Delivery						Maximize patient care through autonomous technologies in operational environments

Thrust 2: Intelligent, Adaptive Aiding

Delivering the Mission

- Maintain mission effectiveness despite fluctuating demands: No mission degradation in a high tempo environment
- Optimized human-machine teaming: Dynamic workload allocation to improve mission efficiency
- Provides shared situation awareness and transparency between the operator and the weapon system platform: Appropriate level of operator trust
- Optimized warfighter readiness and enhanced training: Identification of relevant biomarkers indicative of operator cognitive and physiological state

Delivering Capability

Enhance warfighter effectiveness by coupling humans and machines through the use of intelligent adaptive aids to protect from being overwhelmed by complexity and workload.

- Develop models of perception and cognition
- Assess the functional state of the operator
- Real-time measurement and assessment of warfighter performance

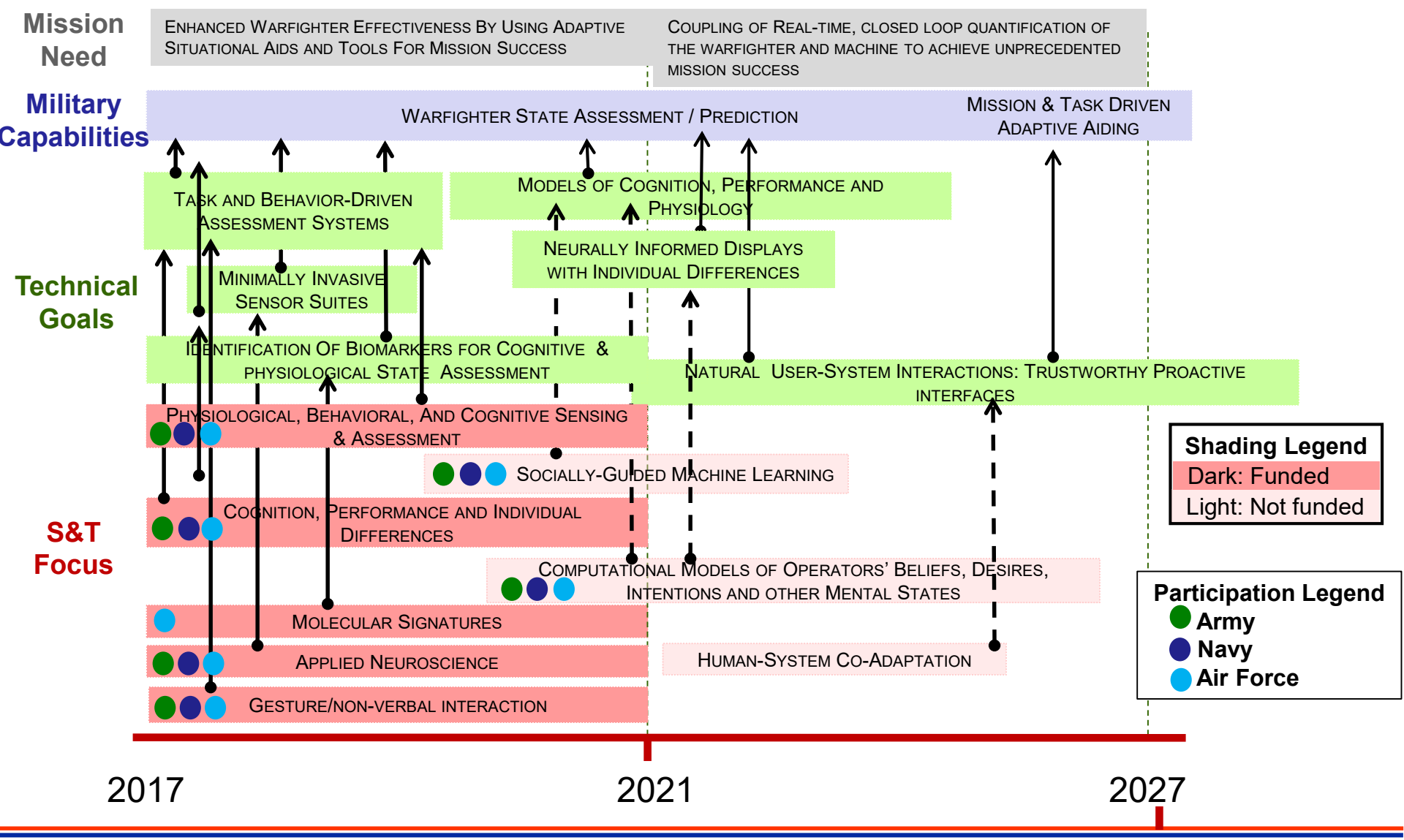
Key Technical Challenges

- Immature tools for individual and team functional state assessment
- Fragile cognitive models
- Operationalize minimally invasive sensor suites
- To Identify the appropriate biomarkers for determining operator performance
- Absence of effective gesture/non-verbal interfaces

Program Overview

- Applied Computational Neuroscience
- Cognitive Performance Optimization
- Monitoring, Predicting, and Optimizing Battlespace Awareness

Intelligent, Adaptive Aiding



Intelligent, Adaptive Aiding
Program Detail

S&T Focus Area	Near-term (FY 15 – FY 19)	Mid/ Far-term	Operational Opportunities
Gesture/Non-Verbal Interaction	Gesture and Non-verbal Interaction Brain-Computer Interaction Applied Adaptive Aiding		Human-machine interaction using gestures and/or other non-verbal means to communicate/execute mission intent.
Applied Neuroscience	Applied Computational Neuroscience Monitoring, Predicting, and Optimizing Battlespace Awareness Molecular Signatures Soldier Focused Neurotechnologies		Real-time, omnipresent-sensing technology, signatures of brain networks that capture changes in task performance and brain-based technologies to aid the operator and optimize team performance.
Cognition, Performance, and Individual Differences	Cognition, Performance and Individual Differences Cognitive Performance Optimization Soldier Centered Design Tools		Advanced technology to sense, measure and quantify individual warfighter cognition and performance parameters to predict and augment warfighter performance.
Physiological, Behavioral, and Cognitive Sensing and Assessment	Applied Computational Neuroscience Soldier Focused Neurotechnologies Continuous Multi-faceted Soldier Characterization for Adaptive Technology Advancements Molecular Signatures Cognitive Performance Optimization Applied Adaptive Aiding		On-line operator monitoring and assessment technology, integrating multiple and concurrent data streams to predict and augment warfighter performance.

Protection, Sustainment, and Warfighter Performance

HUMAN SYSTEMS COI SUB-AREA:
Protection, Sustainment, and Warfighter Performance

VISION

Enable superiority of Warfighters by understanding and overcoming operational stressors, and providing protection from threats in their environment.

DARPA Warrior Web early prototype

Wearable sensor technology

This will be achieved through:

1. Understanding the factors that influence individual performance
2. Developing the ability to measure performance in the operational environment
3. Developing strategies to mitigate the effects of critical stressors on performance

Achieving this vision will enable:

1. Increased ability to perform at a higher stress level without a performance decrement or increase in injury
2. The ability to measure performance in training and operational environments
3. Warfighter protection aligned to mission specific threat, environment, and region allowing for optimal performance while maintaining protection
4. New technology capable of measuring current Warfighter state and predicting current and near term performance, resulting in 20% increase in task performance
5. Load mitigation strategies resulting in 25% decrease in metabolic cost

Protection, Sustainment, and Warfighter Performance Scope

Research and development in this area will produce better understanding of the critical environmental stressors and the human factors yielding individual performance differences in operational environments in order to enhance performance and mitigate the effects of stressors. This includes designing systems that support and exploit individual differences, and developing operationally relevant metrics to monitor and assess performance.

Thrust Area 1:

Understanding and Quantifying Warfighter Variability

S&T Focus Areas on Roadmap:

- Ability to Conduct Warfighter Assessment in All Environments
- Mechanisms and Effects of Individual Differences and Critical Stressors on Warfighter Performance
- Real-Time Data Analysis and Performance Prediction

Thrust Area 2:

Enhancement and Mitigation Strategies

S&T Focus Areas on Roadmap:

- Tool(s) for conducting trade off studies between protection/load, performance, and individual differences.
- Development of Augmentation Technologies and Techniques
- Design and Development of Models and Methods for Understanding Effects of Mitigation Strategies

Thrust 1: Understanding and Quantifying Warfighter Variability

Delivering the Mission

- Data analysis and performance prediction will enable improved resilience by providing critical information on Warfighter readiness.
- Understanding the underlying mechanisms through which critical stressors influence performance will enable greater performance and protection methodologies.
- Understanding individual differences in the effect of critical stress on performance will enable greater Warfighter resilience.

Delivering Capability

- Developing technology capable of objectively measuring warfighter performance in operational environments to enable real-time monitoring of Warfighter performance.
- Understanding the underlying mechanisms through which performance is influenced will provide a pathway to optimizing Warfighter performance.
- Modeling individual responses to critical stressors will enable the leveraging of individual variability as a means of improving Warfighter performance and protection.

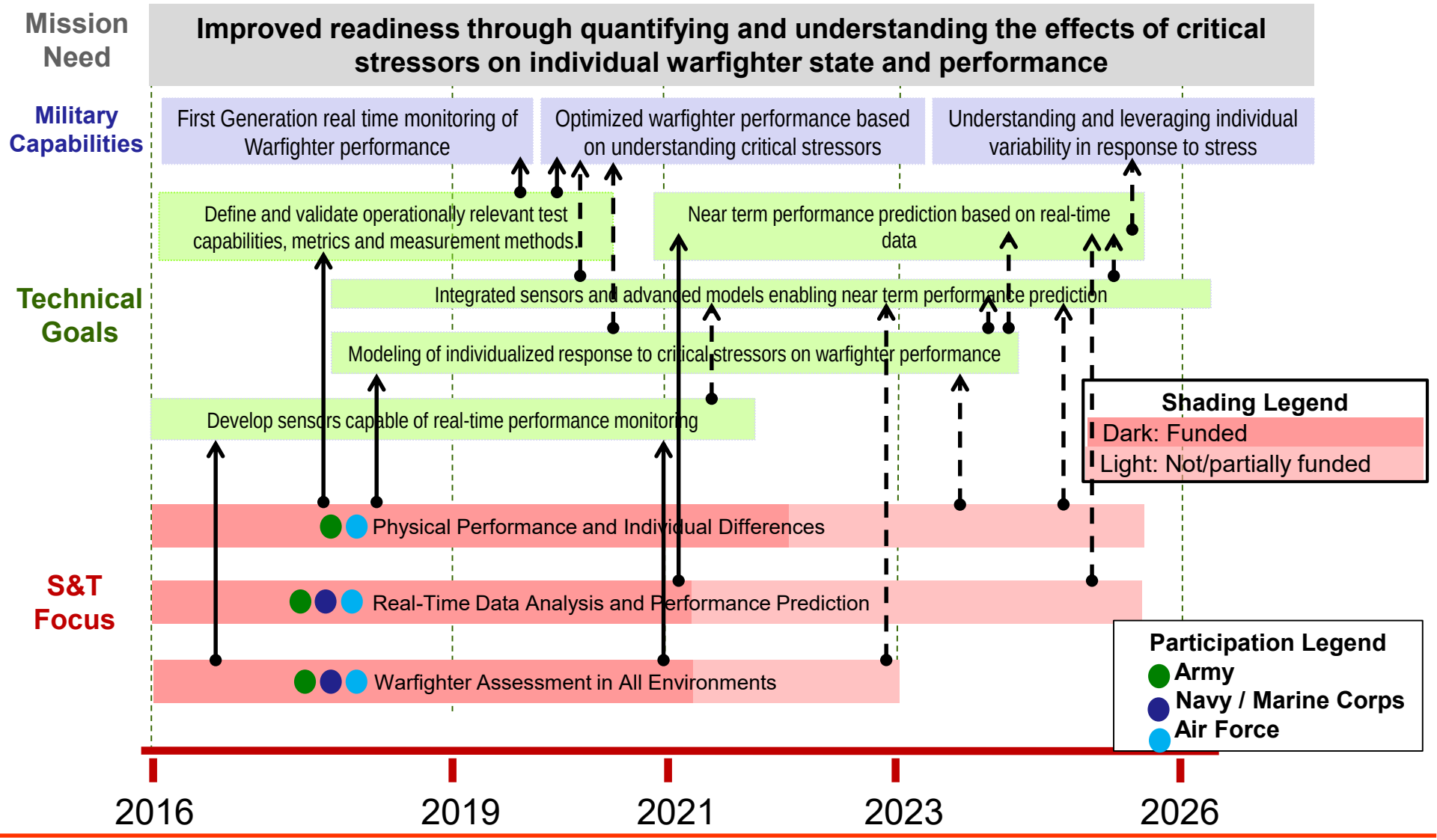
Key Technical Challenges

- Sensors needed that are non-invasive, don't influence performance, and provide meaningful data.
- The underlying mechanisms by which specific stressors influence performance are poorly understood.
- The influence of human variability on the effects of stress on warfighter performance is difficult to predict.
- High fidelity models that predict performance and injury and/or the impact of protection strategies on performance are lacking

Program Overview

- Determinants of hazardous biomechanics
- Ubiquitous and unobtrusive Real-World Assessment
- Impact of individual differences

Understanding and Quantifying Warfighter Variability



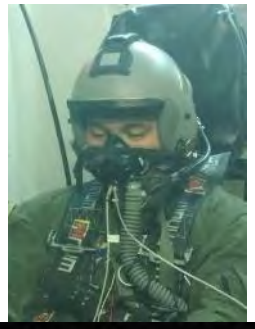
Understanding and Quantifying Warfighter Variability
Program Details

	Near-term					Mid/ Far-term	Operational Opportunities
	FY 15	FY 16	FY 17	FY 18	FY 19		
Physical Performance and Individual Differences *Understanding the effects of physical stress and of individual variability on the effects of that stress on performance.*	Determinants of hazardous biomechanics and injury Bioeffects:toxic particles, nanomaterials, directed energy exposures Effects of operational environment on pilot toxicology Human Integrated Performance Optimizer Advanced Research focusing on Individual Differences						*An understanding the individualized effects of critical stressors on physical performance will enable greater warfighter resilience.*
Real-Time Data Analysis and Performance Prediction *Developing the ability to predict near and far term performance decrements before they happen.*	High resolution, wearable kinematic sensor and real-time algorithms development → Feedback to improve Warfighter Performance → Sustainment Technologies for Enhanced Performance of Soldiers (STEPS) Real-Time Bioeffects analysis						*Real-Time information on Soldier state and impending performance decrements will provide critical information on Soldier readiness.*
Warfighter Assessment in All Environments *The development of metrics and tools for quantifying Warfighter states in any environment.*	IMU Arrays for Warfighter Kinematic Measurement Omnipresent Real-World Soldier Assessment Aerospace Toxicology Human on a Chip → Integrated Sensor Suite Development → Probabilistic Risk Assessment Tools for Weapons Developers →						*The ability to collect information on Warfighter state in the operational environment. This information can be used to prevent performance decrements.*

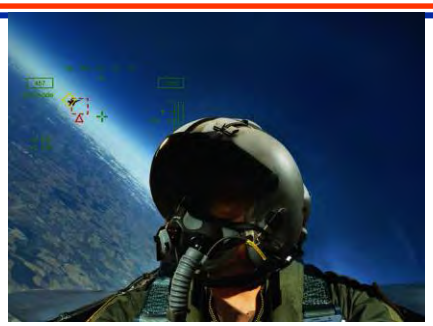
Pilot Physiological Monitoring and Warning System (PPMAWS) Technology Demonstration

International CRADA Elbit/LifeBeam Helmet Testing

Foreign Comparative Test PPMAWS integration into Joint Helmet Mounted Cuing System



PPMAWS Demonstration Altitude and High-G Acceleration



Next Gen JHMCS

2013 2015 2016 2019

Thrust 2: Enhancement and Mitigation Strategies

Delivering the Mission

- Physical augmentation to reduce metabolic cost by up to 25%
- Modeling and Simulation tools capable of predicting physical stress on the Warfighter to within 5%.
- Optimized load configurations and route planning leading to a 10% reduction in metabolic cost and 10% increase in operational performance.

Delivering Capability

- Develop methods of lessening the effects of critical stressors on Warfighter performance
- Understand the underlying mechanisms by which physical augmentation and protection technologies affect performance. Set system requirements.
- Provide the tools (M&S, route planning, etc.) necessary to understand the relationship between new technology, mission requirements and operational effectiveness.

Key Technical Challenges

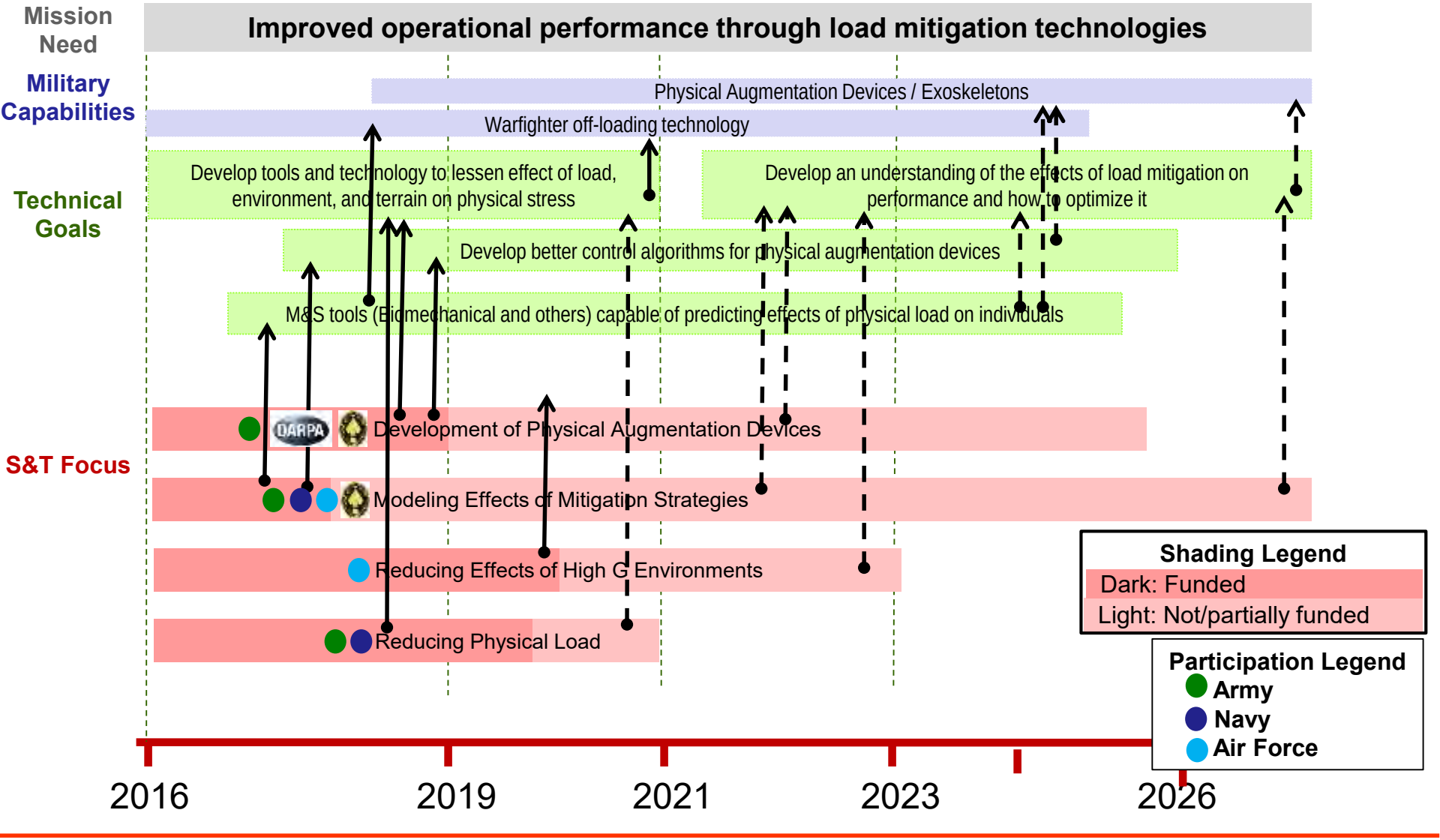
- Tools to model effects of augmentation on physical performance and injury potential are still in development.
- Route planning tools require high fidelity models of human physiological response to critical stressors.
- Individual variability influences the extent to which physical augmentation can mitigate physical loads

Program Overview

- Lower Extremity motor adaptations to actuation
- Effects of physical augmentation on walking efficiency
- Enhanced Technologies for Optimization of Warfighter Load

Photo property of MIT Prof. Hugh Herr 75 Amherst St., Rm. E14-374L, Cambridge, MA, 02139, (t) 617-258-6574, hherr@media.mit.edu

Enhancement and Mitigation Strategies



Enhancement and Mitigation Strategies
Program Details

	Near-term					Mid/ Far-term	Operational Opportunities
	FY 15	FY 16	FY 17	FY 18	FY 19		
Development of physical augmentation *Devices designed to lessen the effects of physical load on the Warfighter*	DARPA Warrior Web						*Increased endurance, decreased physical fatigue, improved performance.*
	Tactical Assault Light Operator Suit (TALOS)						
	Lower Extremity Adaptations to Joint Actuation						
	Human Body adaptations to physical augmentation						
	The Effects of Training on the Efficacy of a Physical Augmentation Device						
					Advanced control algorithms for enhanced augmentation		
	Ankle Exoskeletons to assist Load Carriage						
Modeling effects of mitigation *M&S aimed at improving augmentation devices and better understanding their effects*	Joint Biomechanical Modeling and Simulation Initiative						*Augmentation devices that are better suited to the user, resulting in increased physical performance, and less cognitive decrement resulting from physical fatigue*
	Enhanced Technologies for Optimization of Warfighter Load						
					3-D Modeling & Spinal Injury Assessment		
	Advanced Human Whole-Body Response Model						
Reducing Effects of High G Environment *Efforts aimed at reducing the effects of high G environments for pilots*						Hypersonic Escape	*Increased pilot performance in high G environments, decreased injury*
						Next Gen Escape Systems Concepts for Pilots	
	Repetitive G-Loading mitigation for Pilots						
Reducing Physical Load *Technology aimed at reducing the physical load (actual weight, 'easier' terrain, etc.) a warfighter needs to traverse.*	NSRDEC Route Planning Tool						*The ability to reduce Warfighter physical load while maintaining capability and performance.*
	Energy Harvesting BackPack						
	Load Carriage / Novel Load Mitigation studies						

Accomplishments

- **OBOGS – Mil Standard 3050 developed (Bi-service Air Force/Navy). OBOGS' oxygens systems and their standards (operating and contamination standards).**
- **Multiple wearable robots are showing reduced metabolic cost during walking (treadmill and overground)**
- **Warfighter variability within field based settings**
  - IMUs from lab to field, now instrumenting Warfighters with IMUs and getting kinematics and more in depth performance metrics in the field. Providing more in depth information than that which is gained solely from SME opinion. Think dashboard. What value does this provide?
- **Laser Eye Protection ATD**

Thank You

Success Story: Autonomy Research Pilot Initiative
Realizing Autonomy via Intelligent Adaptive Hybrid Control

Operational Challenge

Autonomous control of multiple unmanned systems for military operations

Problem: Current fielded systems fall far short of desired advanced, highly reliable autonomous cooperative behavior

Objective: Increase the robustness and transparency of autonomous control for multiple unmanned systems

Outcome: Agile and robust mission effectiveness across a wide range of situations, and with the many ambiguities associated with the "fog of war"

S&T Accomplishments

- ❑ Refined tri-service "Base Defense" challenge scenario to include more unexpected, dynamic events
- ❑ New rapid joint human-machine "Course of Action" tool
- ❑ New Task Manager capability: system workload balancing
- ❑ IMPACT "DoD Virtual Lab" refined (Year 2)
  - ❑ 1 operator x 12 vehicles (simulation)
- ❑ IMPACT Year 2 full system evaluation underway with 8 op experts
- ❑ Co-development of R&D at ARL, NRL and SPAWAR
- ❑ To date, over 30 S&T publications produced

Return on Investment

Affordability

- Reduction in logistics footprint for equipment and personnel
- Risk Reduction: Opportunities to transition IMPACT technologies to other DoD programs

Readiness

- Force multiplier: Autonomous control of multiple weapon systems with fewer personnel

Success Story:
Multi-Modal Communication Management Suite

Operational Challenge

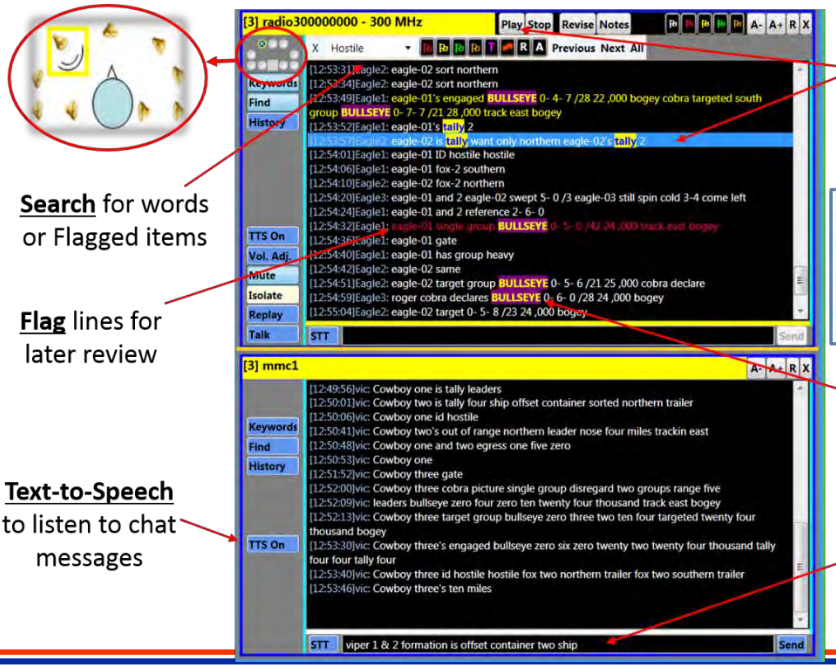
Problem: C2 operators experience a high volume of perishable voice and chat communication across disparate systems leading to high workload and missed messages.

Objective: Provide comprehensive communication management software that improves real-time operator performance and workload in high comm situations.

Outcome: Net-centric software with integrated voice and chat, spatial audio, automatic speech recognition, keyword spotting, communication recording, search, and playback.

S&T Accomplishments

- ❑ Software prototype with licensed patent on IP
- ❑ Lab evaluations showing increased key-word spotting performance and reduced operator workload
- ❑ Integration into AFRL/FAA/Naval Undersea Warfare Center research testbeds
- ❑ Collaboration with Carnegie Mellon on custom speech recognition models for FAA and Domestic Event Network
- ❑ Integration and operational demonstration at Western Air Defense Sector
- ❑ Cooperative Research and Development Agreement with Global Flyte to tailor for emergency response scenarios



Search for words or Flagged items

Flag lines for later review

Text-to-Speech to listen to chat messages

Listen to past audio by selecting desired text

Radio communications are transcribed using ASR

Highlight Keywords - create alerts to critical words

Speech-To-Text sending chat messages

Return on Investment

Affordability: Intellectual Property protected; software based on open source tools and message protocols

Readiness: (TRL 4/5) Concept demonstrated in laboratory and operational settings; CRADA to improve readiness for emergency response domain

Success Story: Capable Manpower
Control Station Human Machine Interface (CaSHMI)

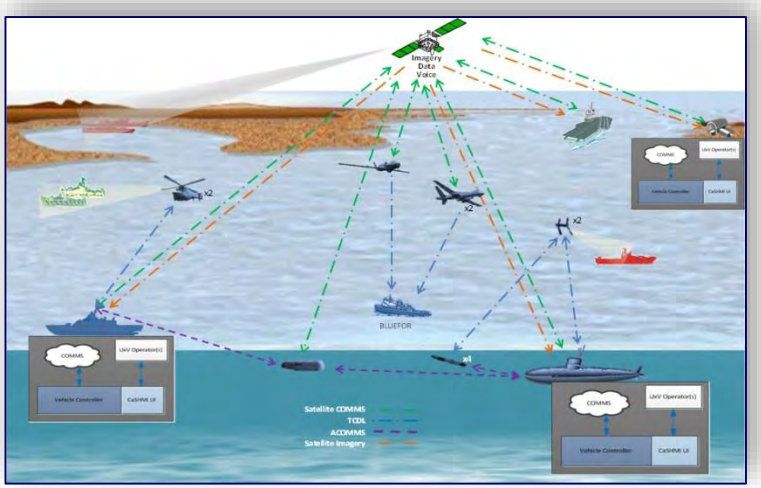
Operational Challenge

Problem:

1) Current UxV control paradigm is manpower intensive with inconsistent, proprietary HMIs.
2) A single UxV, vehicle-centric HMI metaphor does not scale for multi-UxV's, mission management & emerging autonomy

Objective: Develop a Navy Mission-centric HMI, that enables "Parallel management" of multiple UxVs, with intermittent warfighter engagement and will scale with expected automation and technology.

Outcome: Transition UxV supervisory control HMI & supporting software architecture to AN/BYG-1 Submarine Combat System; and PMA-281 Common Control System



S&T Accomplishments

- User-Centered Design Process completed with Cross-Domain UxV operators
- Innovative software architecture defined separating vehicle control from business logic & HMI to enable scalable interface implementations
- Live demonstrations of AN/BYG-1 operators using CaSHMI to provide simultaneous supervisory control of a Blackwing UAS and multiple IVER UUVs concurrently.

Return on Investment

Affordability

- Reduction in manpower requirements for increasing UxV mission employment.
- Reduction in training costs with "common" mission management interfaces

Readiness

- Enable single operator management of 2+ UxVs for an ISR missions
- Flexible task management supports dynamic mission events / requirements
- Prototype for Common HMI & controls across UxVs & Navy platforms

Success Story: Medical Technology Research
Closed-Loop Oxygen Generation and Delivery

Operational Challenge

Closed-loop control of oxygen generation and delivery for military medical operations

Problem: Current military environments present significant challenges to patient care in operational settings (oxygen availability, situational awareness, etc.)

Objective: Induces automatic changes in oxygenation delivery during mechanical ventilation in response to measured changes in patient physiology

Outcome: This technology has the potential to have a profound impact on the way the military medical system cares for critical care patients

Accomplishments

- ❑ Technology has demonstrated, in pre-clinical/clinical models, successful mitigation of hypo/hyperoxemic events (both associated with worsening outcomes)
- ❑ Generated novel mechanical ventilation/oxygen concentrator interoperable system
- ❑ The research team has received an FDA Investigational Device Exemption (IDE) to conduct a first-of-its-kind clinical trial utilizing closed loop control of oxygen delivery during mechanical ventilation in trauma patients

Return on Investment

This technology would maximize safe oxygen delivery and minimize oxygen/power consumption

Affordability

- Conserves oxygen, potentially reduces logistical planning factors

Patient Safety

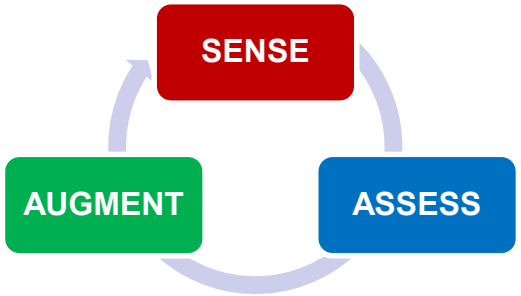
- Maintains clinician set target equivalent to/or more often than standard of care (demonstrated in previous trial)

Readiness

- Force multiplier: Autonomous control of multiple patients with fewer personnel; enhanced care of wounded in austere/resource constrained environments

The Quantified Warrior

Multi-domain Operations



Available wearable sensors can be used to sense the cognitive and physical state of the soldier, sailor or airman.

Success Story: Optimized Warfighter Readiness
Reduction of Sleep Deprivation Induced Fatigue Stress

Operational Challenge

Identification of biomarkers predictive of performance under stress

Problem: Fatigue is an important concern throughout today's 24/7 operations – performance degradations cause mishaps, reduced accuracy & slow reaction time.

Objective: Evaluate efficacy of transcranial direct current stimulation (tDCS) to reduce cognitive declines caused by fatigue.

Outcome: Evidence suggests tDCS is twice as effective and lasts at least 3 times as long as caffeine. In addition, test subjects report feeling less fatigued and more energetic 24 hours post-stimulation.

S&T Accomplishments

- Successfully demonstrated large effects of tDCS on cognition and mood under sleep deprivation conditions
  - Evidence suggests tDCS could be a fatigue mitigation tool more powerful than caffeine.
- Study findings have been replicated within AFRL and outside of AFRL laboratory
  - Illustrates effects are large and robust
- Developed tDCS paradigm (electrode placement, current intensity, stimulation duration) effective for stimulant-like effects

Return on Investment

Affordability

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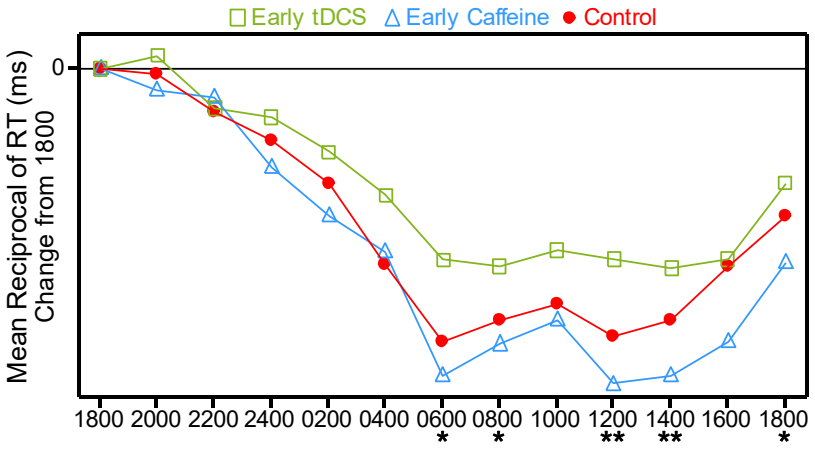


Success Story: Human-Machine Integration
Advanced Wearable Technology for Dismounted Operators

Operational Challenge

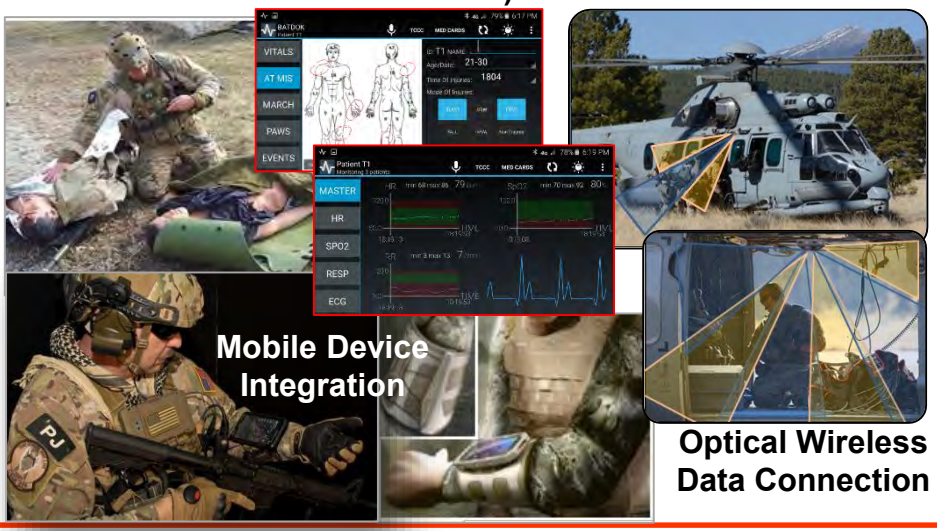
Dismounted operators require greater situational awareness (SA) and an integrated tactical ensemble.

Problem: Power/data cable hazards and responsive multiple patient monitoring

Objective: Increase the battlefield airman's SA: easily operate and increase interoperability of BAO & GAO kit components

Outcome: Medical responsiveness on the battlefield; minimize operator's need to "look-down"; and easily operate body-worn devices

BATDOK (Battlefield Airmen Trauma Distributed Observation Kit)



S&T Accomplishments

- ❑ Developed personal area optical data connection to link head-worn devices with body-worn devices such as headsets, HMDs, tablets, radios, etc.
- ❑ Developed person-to-platform optical data connection to link untethered Airmen to mission platforms for wireless communications.
- ❑ Developed sensor/wireless protocol agnostic casualty monitoring application and system
- ❑ Developed EUD multimodal covert/overt dismounted notifications alerting medics of patients' urgent conditions

Return on Investment

Affordability

- Reduction in BAO & GAO kit cost due to the elimination of cabling needed to connect with body-worn devices
- Casualty monitoring device and capability can save lives

Readiness

- Remote monitoring of multiple casualties
- Ease of operating body-worn devices
- Reduction in cable hazards
- Reduced training spin-up

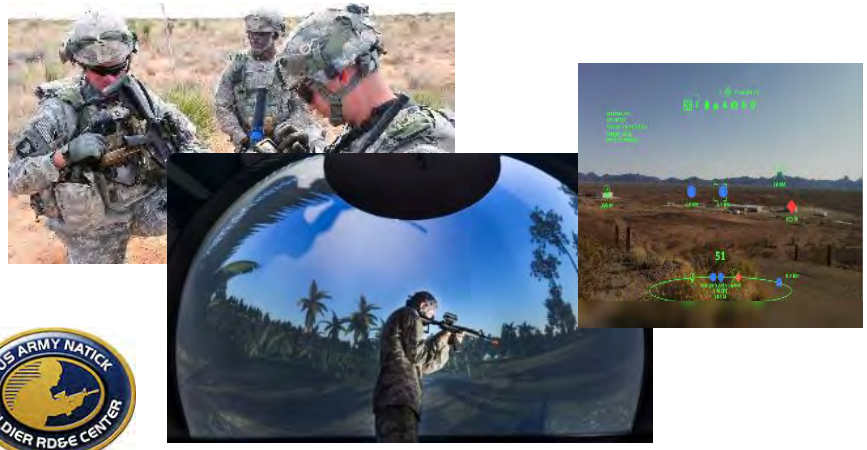
Success Story: Cognitive Assessment Metrics and Emerging Reality Augmentation (CAMERA)

Operational Challenge

Problem: New sensing technologies require Warfighters to make accurate decisions based on a myriad of data while operating in chaotic environments, but assessing human use of Situational Awareness (SA) technologies in standard mission sets has not been formalized.

Objective: Develop validated cognitive workload measures and metrics to assess the impact of SA technologies on Soldier cognitive workload. Develop initial standards for cognitive and mission performance for Dismounted Soldier tasks and select Mounted Soldier duty positions.

Outcome: Increased Situational Awareness during operational missions with minimized SA technology cognitive burden on Soldier and Small units.



S&T Accomplishments

- ❑ Developed scenarios designed to variously tax cognitive workload and SA
- ❑ Developed a high-fidelity PACOM environment with local national and insurgent behavioral profiles, realistic weather, wildlife, and audio
- ❑ Completed pilot studies to establish test methodology for means to collect physiological metrics such as voice data, eye movements/pupillometry, and electroencephalogram
- ❑ Approved FY17 STO-R to develop standard documented test bed to assess impact of new SA systems on decision-making and workload during development cycle

Return on Investment

Affordability

Common Dismounted Soldier viewing and computer control experience across handheld, mounted, and thru-sight displays will reduce the costs of developing related technologies and training personnel

Readiness

SA technologies deployed more rapidly, with fewer unknown performance drawbacks, and reduced training time due to validated cognitive assessment and common viewing prior to fielding

Success Story: Computer Generated Forces
Training Executive Agent (TXA)

Operational Challenge

"An integrated LVC training environment with today's battle complexity is essential to improving proficiency across all current and future mission sets." (Naval Aviation Vision 2016-2025)

Problem: High manpower to run complex virtual training

Objective: Make Computer Generated Forces (CGF) more intelligent and adaptive to training objectives

Outcome: Transitioned the Training Executive Agent (TXA) into the Navy's Next Generation Threat System

S&T Accomplishments

- TXA monitors a training exercise and issues "directives" to other CGFs to modify behaviors according to a higher level scenario director (training objectives)
- TXA used in NIFC-CA training scenarios
- Exploring TXA usage on aviation pods, thus providing unique flexible embedded training capabilities

Return on Investment

Affordability

- Aid instructors and "pucksteers" who dynamically controls CGF during execution of a training scenario.
- Reduce number of required "pucksteers", reduce overall training costs

Readiness

- Provide trainees with tactically realistic entities, in realistic complex battle scenarios
- Allow instructors to focus on trainee, not on playing roll in scenario

Aircraft Crew Breathing Systems OBOGS
MIL-STD 3050 - Joint Air Force Navy

Oxygen Technology Evolution

Gaseous Oxygen (GOX) Systems

1920

Liquid Oxygen (LOX) Systems

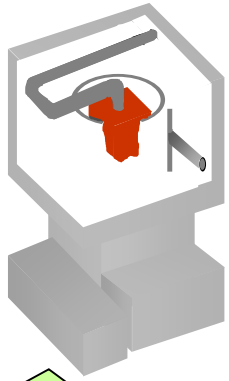
1950

F-15E On-Board Oxygen Generating System (OBOGS)

1990

F-22 On-Board Oxygen Generating System (OBOGS)

2000



Next Generation OBOGS/ Solid State OBOGS

2025

Collaboration for Breakthrough Innovation in Human Performance Monitoring for the Warfighter

NDIA 2018 Human Systems Conference

Dr. Melissa Grupen-Shemansky

Chief Technology Officer, SEMI / FlexTech

megshemansky@semi.org

SEMI: Connect, Collaborate, Innovate


Materials

Equipment


Manufacturing

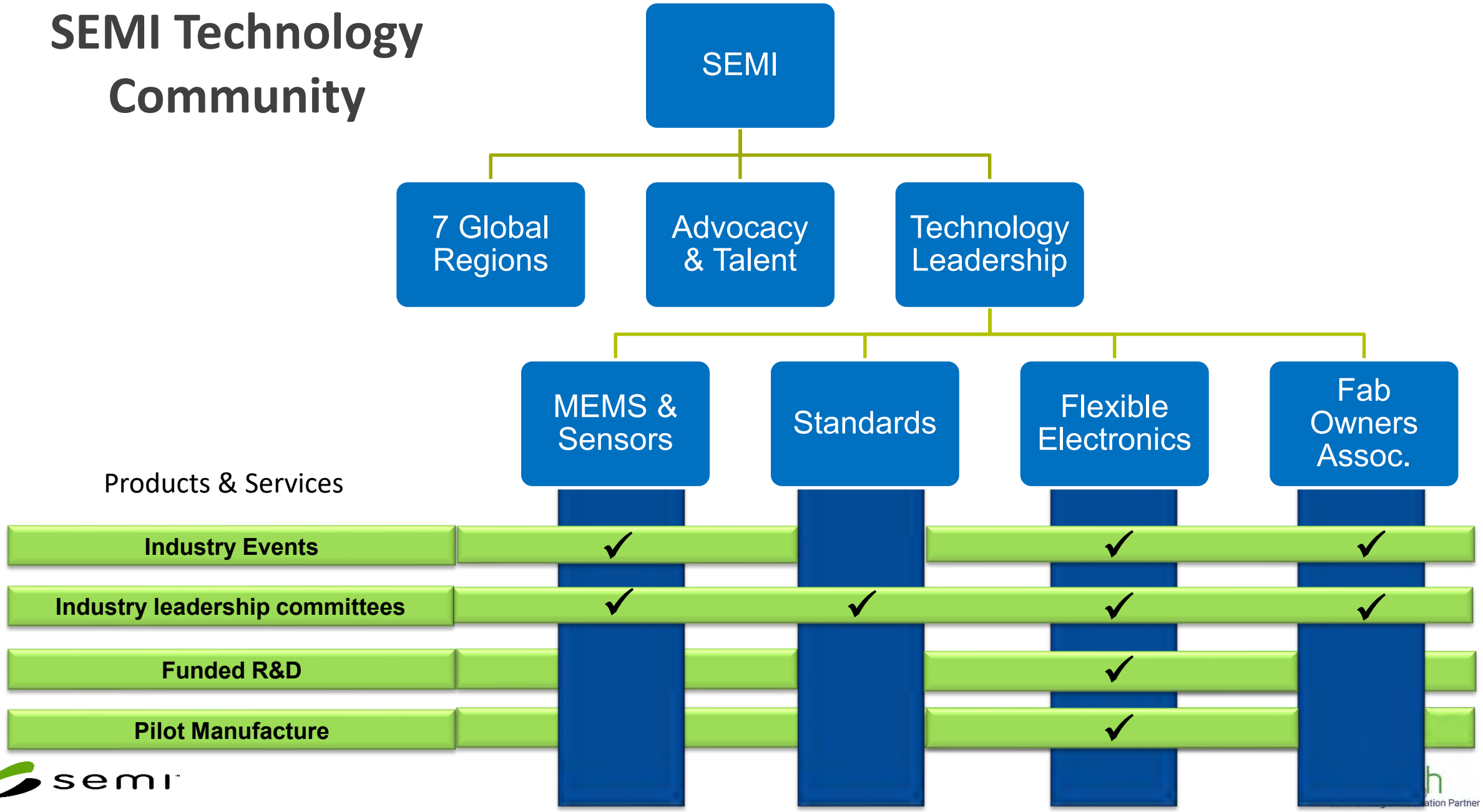

Device


System Integration

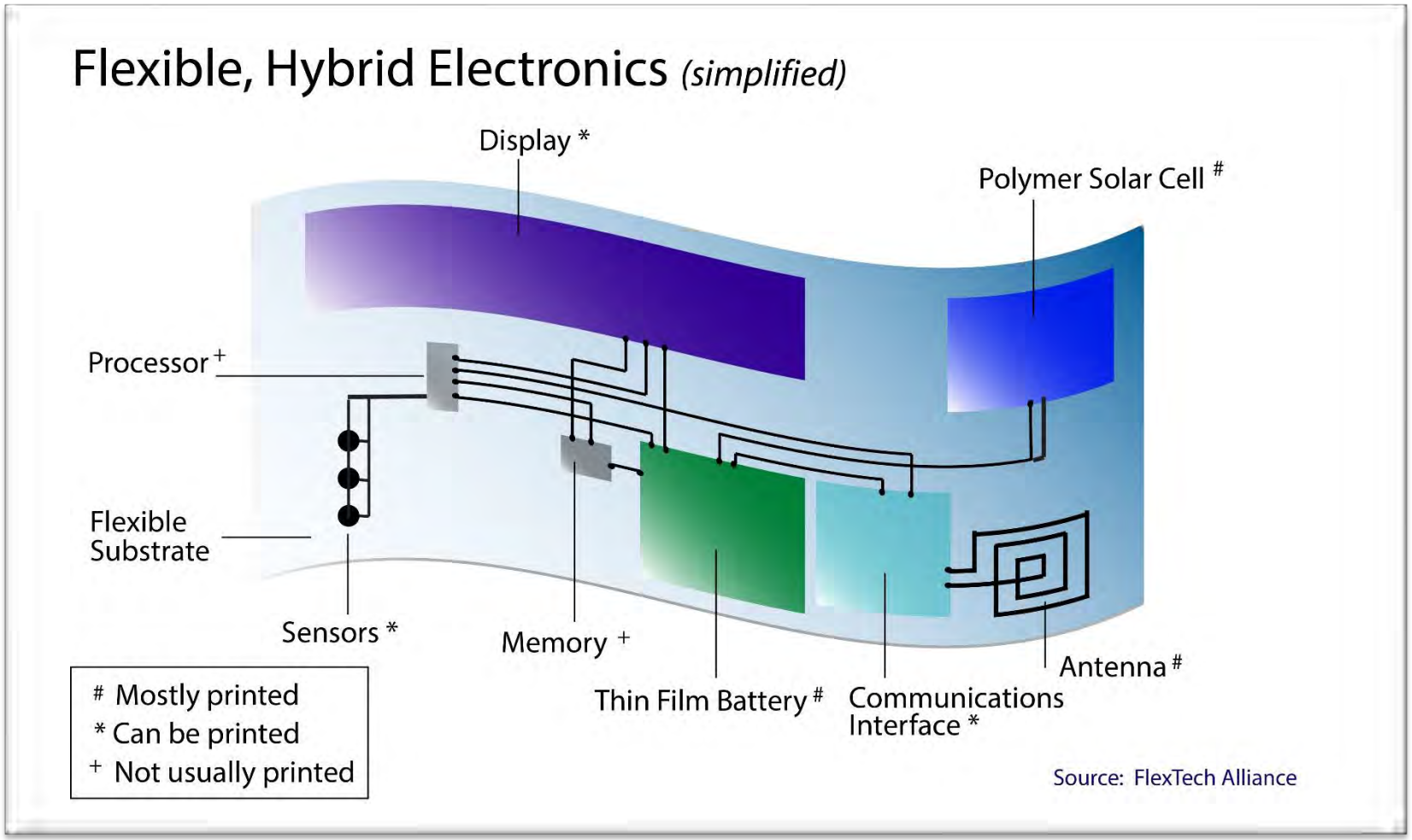

Application Market

- Collaboration is critical to solving issues and innovating new products
- What's needed for breakthrough applications is almost invisible upstream in the supply chain
- Collective focus on challenges and opportunities shortens time to market

SEMI Technology Community



FHE System Schematic



Mostly Printed

- Interconnect
- Antenna

Can Be Printed

- Power
- Display
- Communication Interface
- Sensors

Not Usually Printed

- Processor
- Memory
- Medium to far field communications and location
- High performance circuits

SEMI • FlexTech Activities

Mission: Create a collaborative environment to accelerate the risk reduction of technology, manufacturing, and supply chain development

Flexible Hybrid Electronics Supply Chain Development	Flexible, Wearable Human Performance Monitoring	Flexible Hybrid Electronics Manufacturing
FlexTech	nbmc Nano-Bio Manufacturing Consortium	NEXTFLEX America's Flexible Hybrid Electronics Manufacturing Institute
• CMOS Integration • Radio and communications • Sensing, warnings, wearable displays	• Human Performance Monitoring Applications • 20+ members	• Manufacturing Gaps • Public-private partnership • 50+ members
ARL	Air Force Research Laboratory	Manufacturing USA

Projects & Partners

Sensor Systems | Materials | Power | Hybrid Integration | Design & Integration

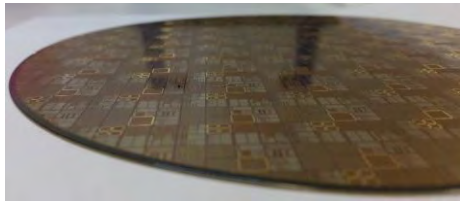
- Wearable Devices for Dynamic Assessment of Hydration & Hydrogen Status
- Wearable Flexible Hybrid Electronics Biometric Performance Monitor
- Design & Fabrication of Prototype Biosensor Monitoring Devices
- Microfluidics System Packaging
- Wearable Dynamic Hydration Assessment System
- Biometric Sensors - Integrated Development Platform for Human Performance Monitoring
- Printed Microfluidic Performance Assessment for Sweat-Based Biomarker Sensor Platforms
- A Scalable Flexible Substrate and Assembly Process
- Flexible Printed Electronic Device
- Materials Registry
- Flexible Electromagnetic Field Sensing Array
- Self-Powered Communicating Sensors
- Sensor Labels
- Flexible Printed Battery
- Thin Film Power Source
- Solid State Thin Film Lithium Rechargeable Battery

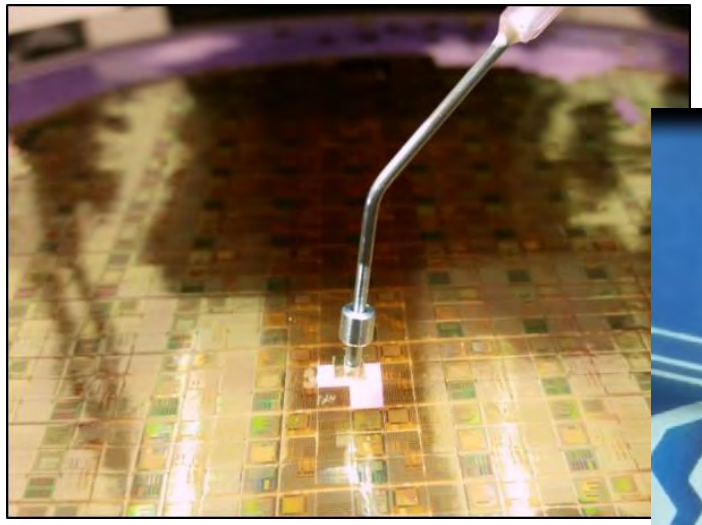
Flexible Silicon

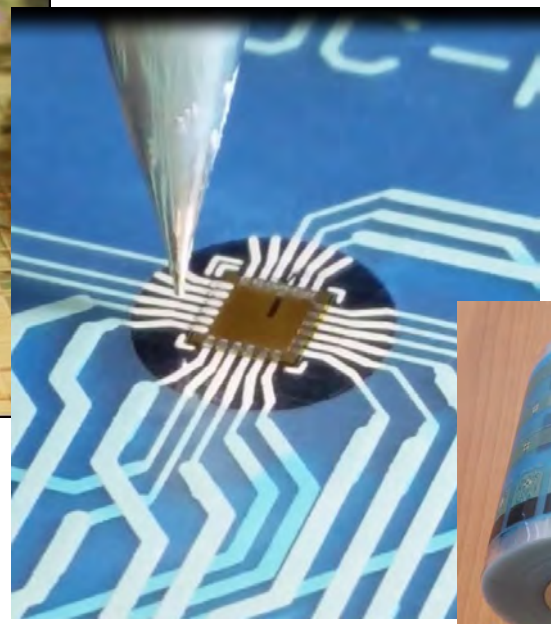
American Semiconductor Inc.

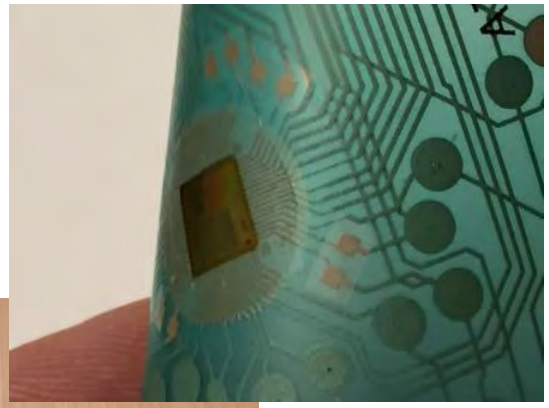
molex
one company › a world of innovation

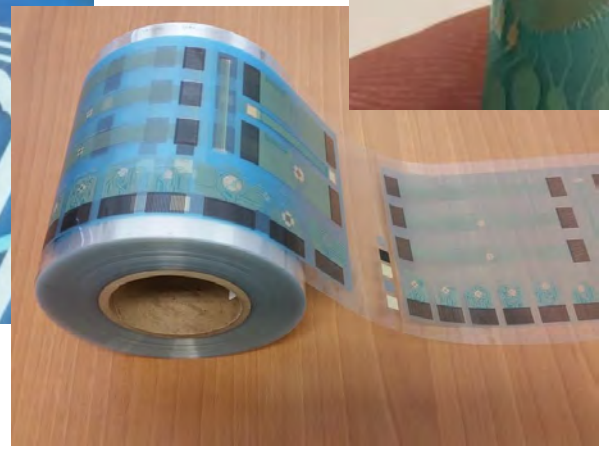
Ultra-thin CMOS
Assembly & multi-layer flexible PCB











CMOS wafer prep

Pick & Place
25 micron total packaged thickness

3D Additive Interconnection
additive print interconnect

Roll to Roll Manufacturing
✓

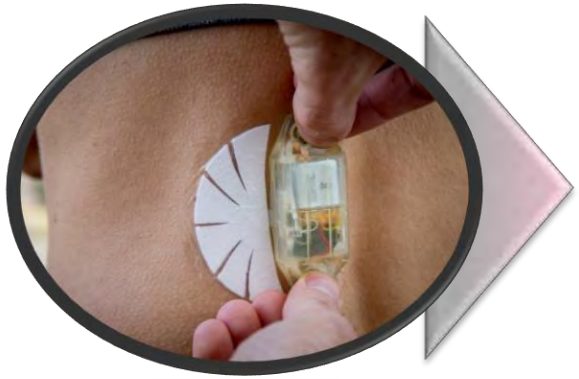
Program supported by:

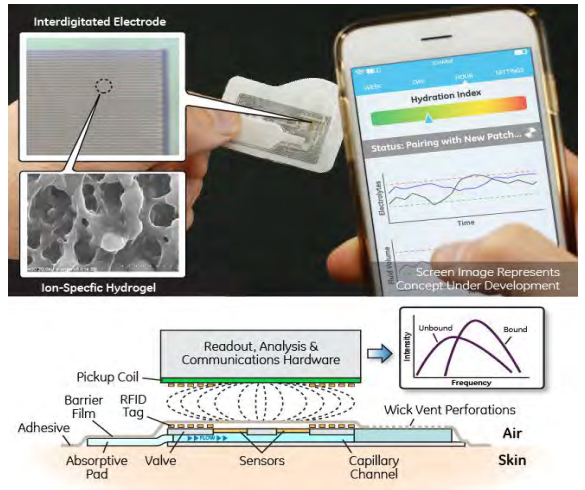
semi

FlexTech
SEMI Strategic Association Partner

Wearable Performance Monitor

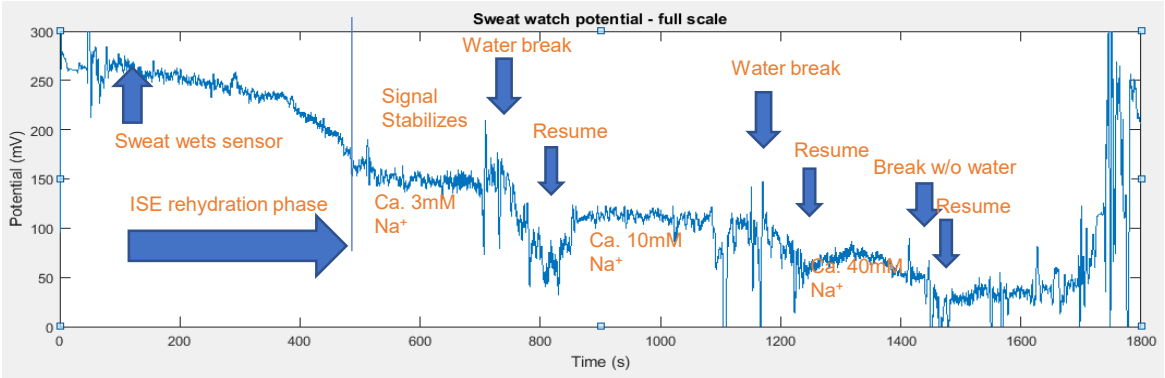
Objective: Develop Flexible, Non-invasive Wearable for Dynamic Assessment of Hydration Status





NBMC Consortium Project 16-10: A Collaborative team of 7 industry and university members lead by GE developed

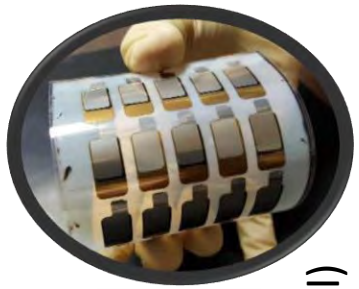
1. Ion Selective Electrodes – Na+ and K+ concentration in sweat
2. RF Impedance Patch – subcutaneous hydration tomography and spectroscopy



Program supported by:

FlexTech
SEMI Strategic Association Partner

Thin Flexible Power Source



ITN Energy Systems Inc. | ENrG Inc. | Lucintech Inc.

Power Module Integration + Advanced Materials + Photovoltaics

Energy Density (Wh/l)

1000
800
600
400
200
0

Self-recharging
Ultra-thin
Power Pack

Primary & rechargeable battery
Capacity 30-90 mAh

Adv. Packaging & Integration

Printing & Lamination

Primary battery
Capacity 30-1000 mAh

Imprint

Panasonic

200 400 600 800 1000

Packaged Battery Thickness (microns)

Program supported by:

semi

FlexTech
SEMI Strategic Association Partner

Medical, Health and Wellness Applications

Cognitive Function

- Military, consumer, industrial, and athletics
- High value assets, safety, performance

Telemedicine

- Vital sign and geriatric patient monitoring
- Reduced health care costs
- Continuous measurement capability

Treatment Response

- Reduce treatment cycle times
- Reduced costs
- Lower mortality rates

Aeromedicine

- Coordinated triage
- Continuous vital sign monitoring
- Variable / austere environment

Performance Monitoring

- Improved health and wellness
- Athletic performance enhancement

Monitoring Requirements

- Cost effective
- Unique accuracy & precise
- Low maintenance
- Automated analytics

Summary

- Target the needs of the military – sustaining and augmenting peak performance of the military personnel
- Align to commercial industry advances and ecosystem development to ensure a stable and advanced supply chain
- Take advantage of other disruptive technologies and address the challenge of incorporating into flexible electronics
  - Artificial intelligence and machine learning
  - Edge computing and new SW/HW architectures
  - Advanced MCU-memory-sensor interfaces
  - Multi-modal sensor data acquisition and management

Thank You

DHS SCIENCE AND TECHNOLOGY

HSI T&E Methods and Metrics for Assessing User-Automation Interaction

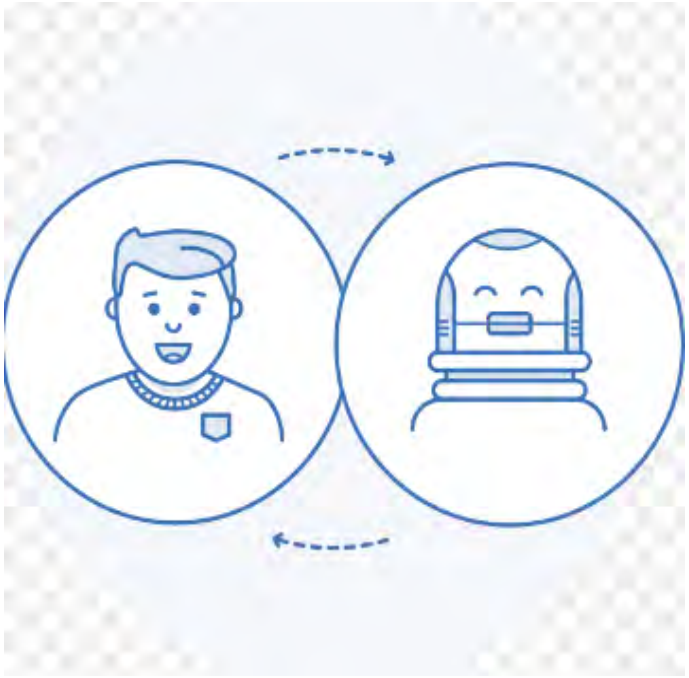
13 - 14 March 2018

Homeland Security
Science and Technology

Mike Barrientos
Transportation Security Laboratory
Bonnie Kudrick
TSA Office of Requirements and Capabilities Analysis
Janae Lockett-Reynolds, Ph.D.
Office of Systems Engineering
Thomas Malone, Ph.D.
Carlow International, Inc.

Agenda

- Definition of Automation
- Allocation of Functions
- Value of Early T&E
- Systems Engineering Life Cycle (SELC)



Automation

Technology by which a machine performs a process or procedure

Advantages

- Reduces human workload, fatigue, staffing
- Integrates large volumes of data
- Improves vigilance, surveillance, and detection
- Increases safety by removing the human from hazardous environments or situations
- Reduces human error
- Expands and extends human capabilities: strength, sensory abilities, and cognitive processes

Disadvantages

- Uses different control strategies than operator
- Elicits the ‘out of the loop syndrome’
- Leads to complacency
- Leads to loss of perishable skills
- Creates mode selection errors
- Interferes with operator situation awareness issues
- Interferes with team coordination

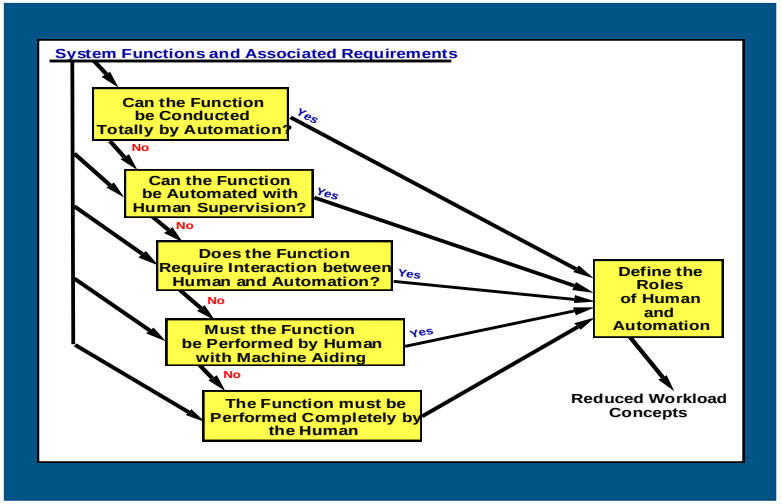
Function Allocation in the system design process

Decisions are made on functions:

- which ones are fully automated
- which ones are performed by a human only
- which ones are performed by a collaboration between automation and human

Criteria for these decisions include:

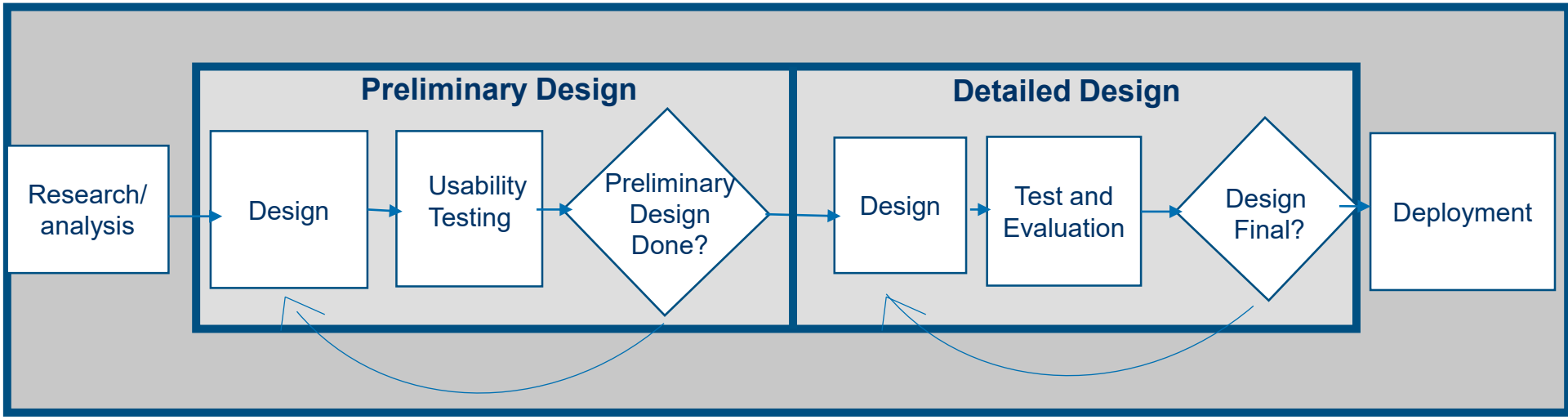
- technology maturation, technical risks, and automation feasibility
- command authority, mission risks, environmental, and operational contexts
- human safety, performance capabilities, and limitations



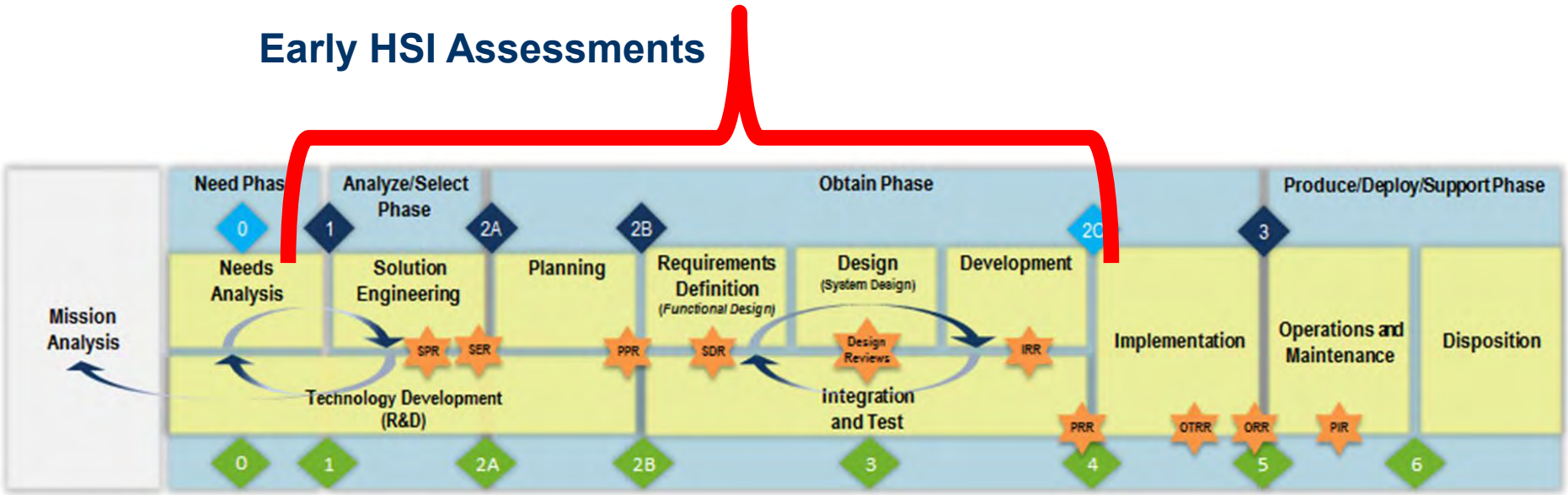
Value of Early T&E

Initiating T&E efforts earlier in the process leads to:

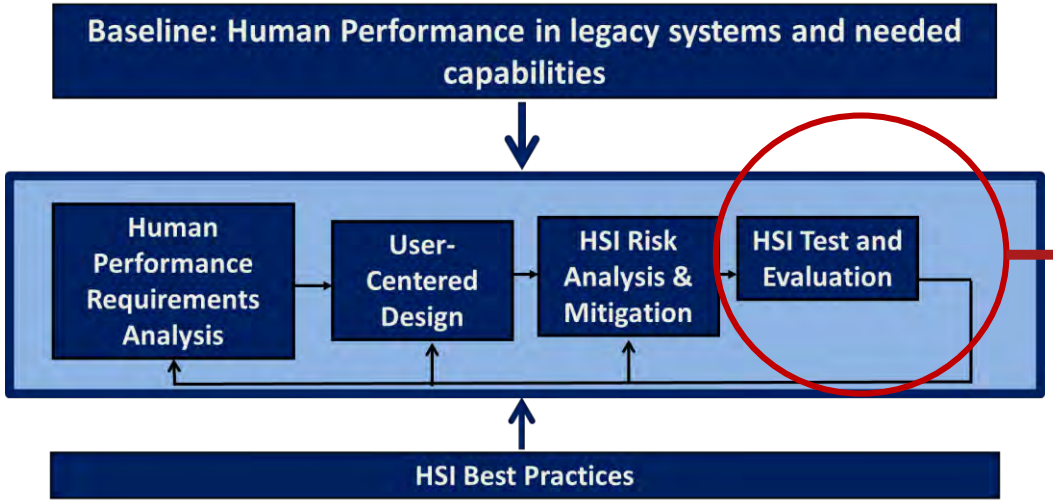
- Successful T&E outcomes through early verification of HSI requirements;
- Early identification and implementation of mitigation strategies to reduce HSI risks;
- Earlier identification of problems that can impact system modifications;



DHS
Systems Engineering Life Cycle



Key HSI Activities



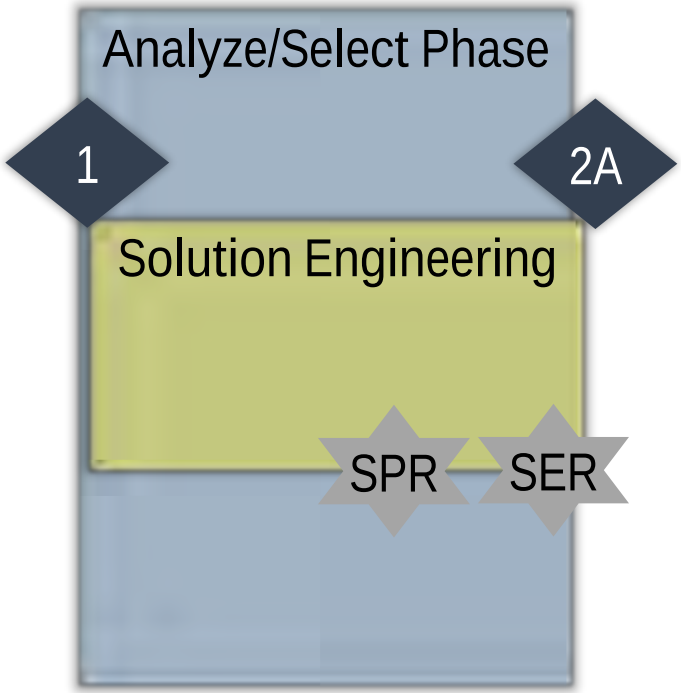
- HSI requirements
- Test objectives
- Measures (e.g., MOSs/MOPs, TPMs and CTPs, and HSI COIs)
- Test methods
- Test design
- Test Plan
- HSI Test activities
- Analysis
- Report

Sample HSI Methods and Measures for Automation

Methods	Measures	Metrics
Direct observation and measurement **Experimentation **Actual operations **Simulated Human-in-the-loop studies Compliance with standards Heuristic Evaluations Checklists Subjective rating scales Surveys/Questionnaires	Usability	Completion rate, number of incorrect decisions/actions, duration of time to respond to a stimulus or complete a task, ratings of satisfaction/acceptance)
	Workload (e.g., task load/task engagement)	Number of instances where task load exceeds threshold, duration period of workload saturation, workload spikes/number of instances or timing situations where the overall workload drops below a set minimum threshold, ratings of perceived workload
	Training (e.g., manual and automated tasks)	Time to train/number of training objectives met
	Mismatches between authority and responsibility	Number of mismatches between authority and responsibility
	Unpredictability	Number of Type 1 (i.e., human cannot predict the need to act in nominal operations)/Number of Type 2 (i.e., human can predict but the timing is uncertain regarding when the action needs to occur) unpredictable actions
	Coherency	Number of resource conflicts resulting in interdependent activities/significant coordination
	Interruptions	Number of interruptions
	Automation boundary conditions	Number of instances/duration when automation is placed outside of boundary conditions, Number of instances where automation does not achieve targets while operating according to its spec
	Adaptation to context	Number of instances where there is an Inconsistent response/work-arounds to overly prescribed function allocation
	Automation reliability	Ratings of trust/degree of overreliance on automation/degree of disuse
	Transfer of control	Duration of time it take to move from a passive to an active state/# of errors
	Situation awareness	Mean Situation Awareness Global Assessment Technique (SAGAT) scores across a number of simulation trials
	Comprehension of system/automation logic	End user rating of the extent to which the automation meets expectations

T&E Activities: Solution Engineering

- Identify applicable HSI MOSs and MOPs
- Evaluate alternative concepts
  - Develop test scenarios
  - Select HSI methods to assess function allocation approach and define roles of human and automation
- Identify HSI operational requirements and critical operational issues

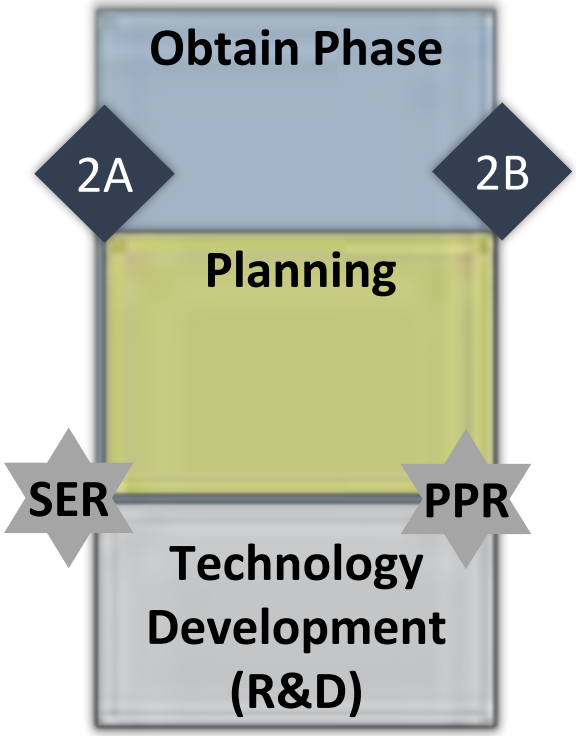


Operational Requirement: The solution shall enable users to successfully complete mission tasks with reduced workload (Threshold = X and Objective = X)

COI: Does the design of the automation coupled with user training support the users in successfully accomplishing mission tasks and minimize the deskilling of automated tasks?

T&E Activities: Planning

- Provide HSI inputs to the TEMP (Test and Evaluation Master Plan).
  - HSI-specific tests
  - HSI tests as part of system-level testing
- Develop an HSI test strategy
- HSI participation in a T&E IPT
- Provide HSI Critical Technical Parameters (CTPs)

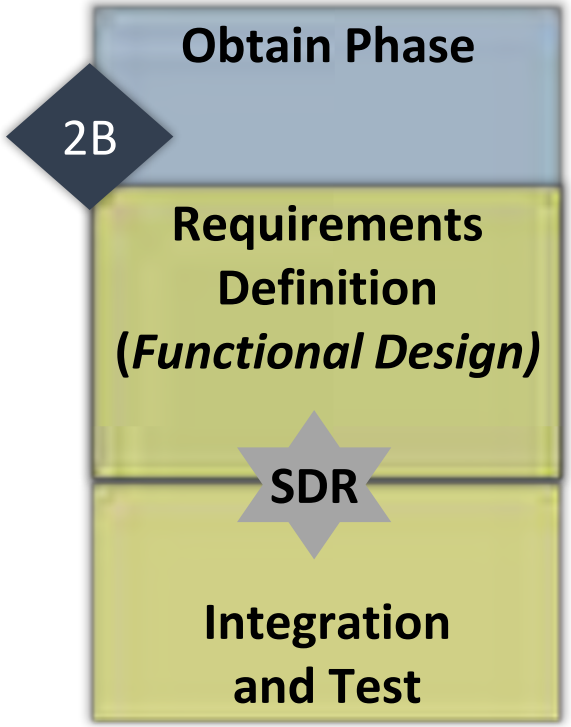


HSI Measures:
Usability
Situation Awareness
Coherency

Critical Technical Parameter:
Task completion/error rates for task work/teamwork,
Mean SAGAT scores
Number of resource conflicts due to overlap in functions

T&E Activities: Requirements Definition

- Determine how HSI T&E activities will refine requirements.
- Determine how HSI T&E is used to assess the adequacy of commercial or COTS products.
- Refine requirements through experimentation and modeling and simulation.

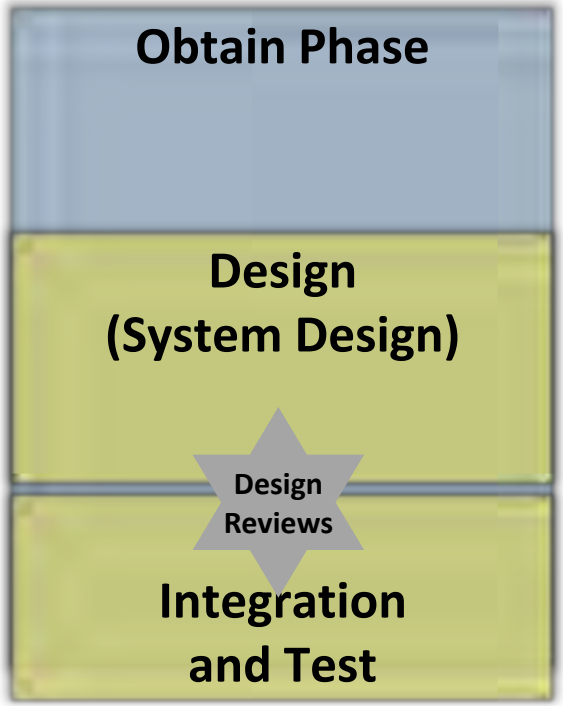


Requirement: System function allocation concept shall support the dynamics of the work

Experimental Design: 2 X 2 X 3 (12 conditions)
IVs: allocation concept, experience level, task demands
DVs: time spent in cognitive control modes and transitions between control modes

T&E Activities: Design

- Develop HSI inputs to the DT&E test plan
- Common methods (analysis, test, demonstration, inspection)
- Iterative testing and evaluation to assess user performance of human-automation interaction
  - Usability, situation awareness, workload, function allocation concepts

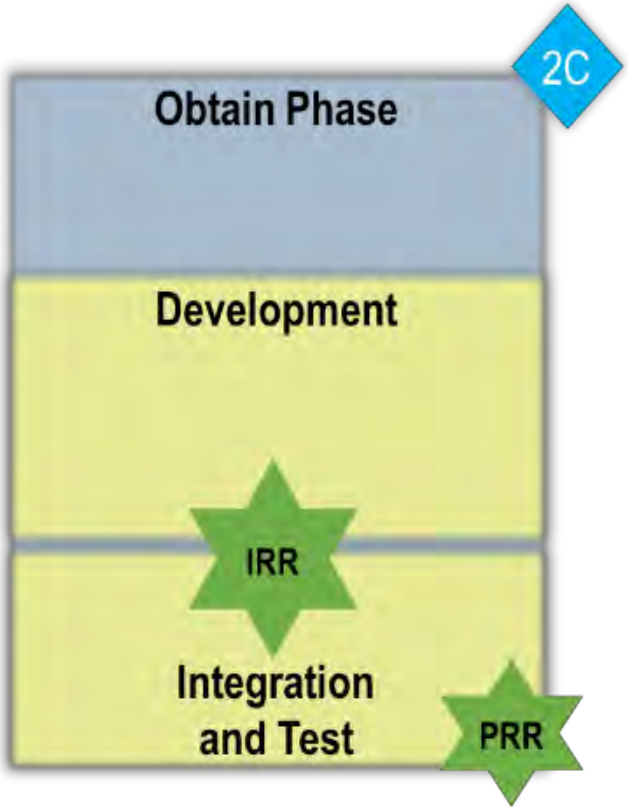


Requirements:
System shall provide adequate early warning notification
System shall not interrupt at inappropriate times (e.g., periods of high workload)
System shall enable the user to determine asset health, status, and place in a procedural sequence

T&E Activities: Development

HSI testing of components, products, and functionality that make up the system

- Evaluate human performance against TPMs to assess progress towards meeting system performance requirements
- Identify HSI risks and mitigation strategies



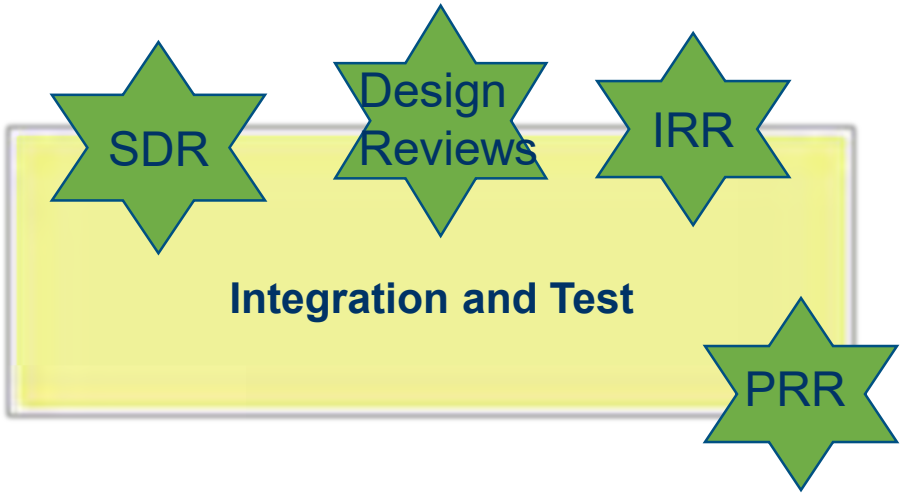
HSI Risks:

- If automation overly prescribes a course of action or sequence of activities, then users may establish work-arounds or stop using automation
- If authority for task execution and responsibility for the outcome are not assigned to the same "agent", then increased workload due to monitoring associated with the mismatch may occur

T&E Activities: Integration and Test

Determine if integrated system, subsystems, and components satisfy HSI requirements (DT and OT):

- Coordinate with OTA so that Early Operational Assessments address progress toward meeting HSI COIs
- Assess system risks and maturity
- Identify and implement risk mitigation plans and corrective actions



Assess human-automation collaboration effectiveness & efficiency in the completion of mission tasks in representative environments using engineering simulations with prototypes and actual systems

In closing…

- There are benefits to “shifting left” and assessing HSI considerations earlier in the acquisition process.
- T&E must evaluate decisions concerning verification of type/level of automation.
- Modern DHS systems increasingly exhibit automated processes (security network monitoring, revenue collection systems, explosive threat detection systems, remote video surveillance systems, etc.)
- Unique opportunities exist for designing automated technology and systems that facilitate teamwork and cooperation

Questions?


U.S. DEPARTMENT OF HOMELAND SECURITY
Homeland Security
Science and Technology

HSI T&E – Typical Measures

- MOEs (Measures of Effectiveness) are derived through an analysis of the mission by initially defining the top-level mission tasks (capabilities) required to be performed, regardless of the potential solutions.
  Typically, human performance is not addressed in MOEs.

- MOSs (Measures of Suitability) are critical operational measures of success that define whether the alternative is a suitable solution. MOSs include items such as the impact of the alternative on the users (e.g., human system integration, accessibility, compliance, privacy, tactics, training) or the public (e.g., flow of commerce, environmental impact) as well as sustainability and support requirements.

- MOPs (Measures of Performance) are specific, technical performance parameters that can be measured and contribute to the MOEs/MOSs.

711th Human Performance Wing

Integrity ★ Service ★ Excellence

Developing an Autonomous Task Manager for Intelligence, Surveillance, and Reconnaissance Human-Machine Teams

NDIA Human Systems Conference
3/11/18

Jennifer Lopez, MA
Mary Frame, PhD
Alan Boydstun, PhD
Analyst Test Bed
711th Human Performance Wing
Air Force Research Laboratory

AFRL

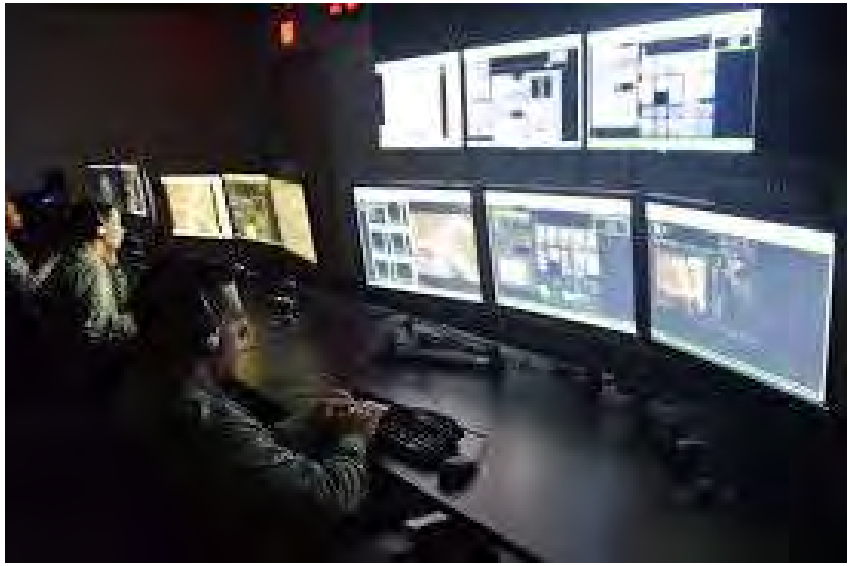
Current Analysts' Challenges Within ISR Environment

- Workload consists of multiple tasks and long shifts
- Work within Human-Machine Teams (HMT) to Process, Exploitation and Dissemination (PED) Essential Elements of Information (EEIs) to customer down range
- Multitasking environment may require automation to improve overall performance (accuracy and efficiency)
  - Reduce repetitive "busy work"

    Examples:

    Copy & Pasting

    Target Detection

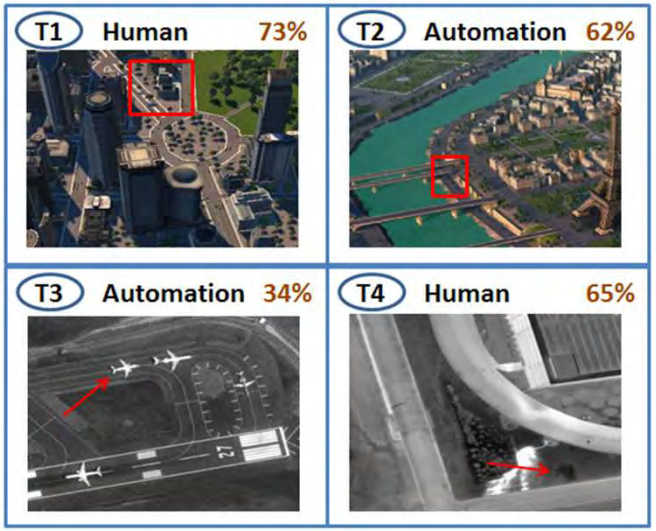


Initial Autonomous Manager (AM)

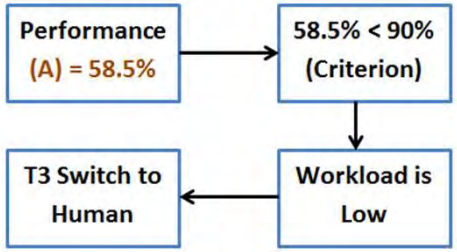
Autonomous Manager (AM) is a "new agent" within the PED cell. Through simulation, AM currently:

- *Intelligently* and *dynamically* parses task allocation in real-time based on agent performance and workload
- Simulates performance with varying prior uncertainty
- Incorporates physiological indicators of human workload (e.g. heart rate)

(a)

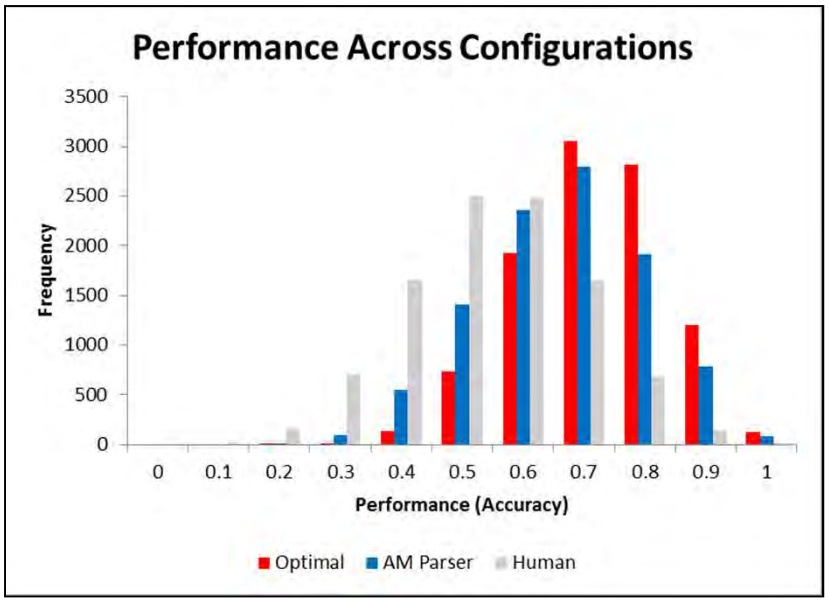


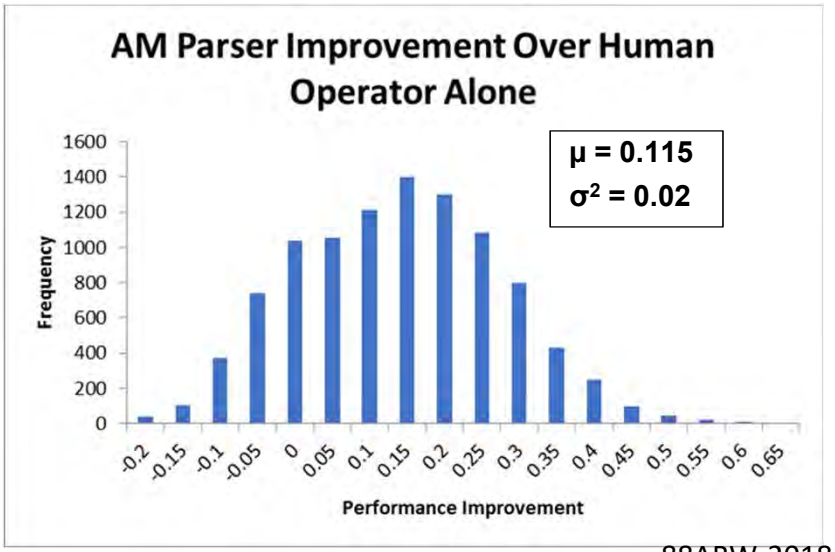
(b)



(a) Multi-INT dashboard of four tasks (e.g. T1, T2, T3 and T4)
(b) Example of task allocation based on performance criteria and workload

AM Simulation Performance





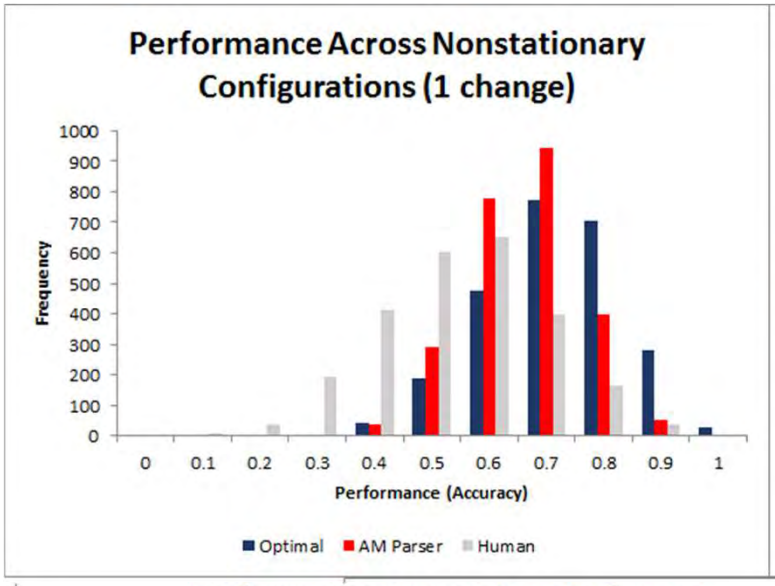
Mean Performance

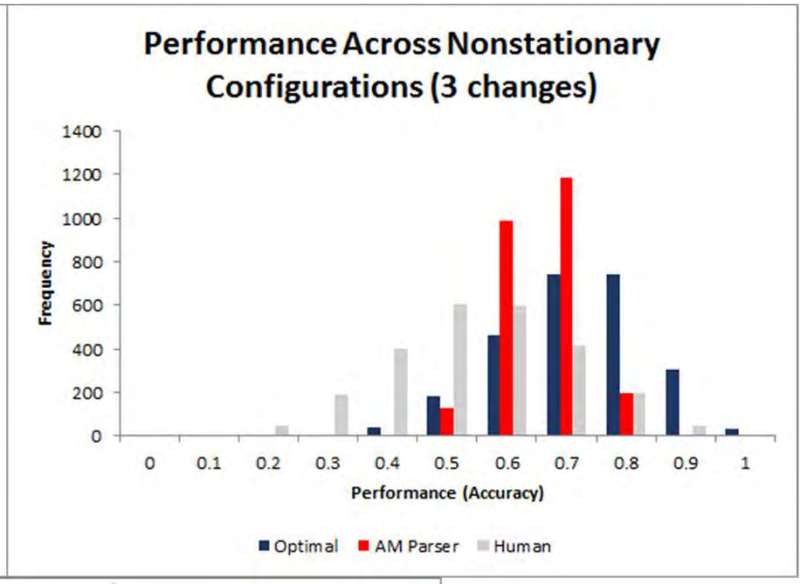
- AM Parser performs 11.37% better than Human baseline
- Optimal Performance performs 5.46% better than AM Parser

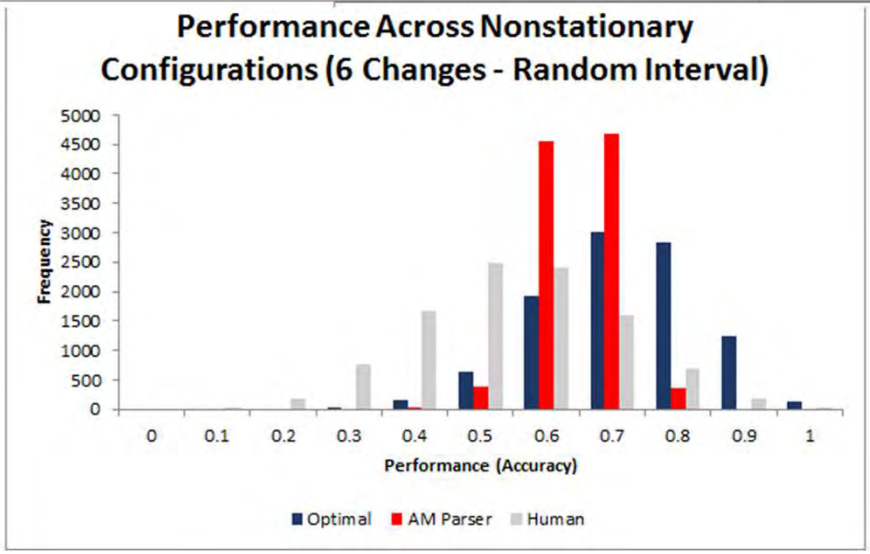
Performance Improvement (Δ)

Under which task conditions do we find greatest and lowest degree of improvement

AM with Nonstationary Performance



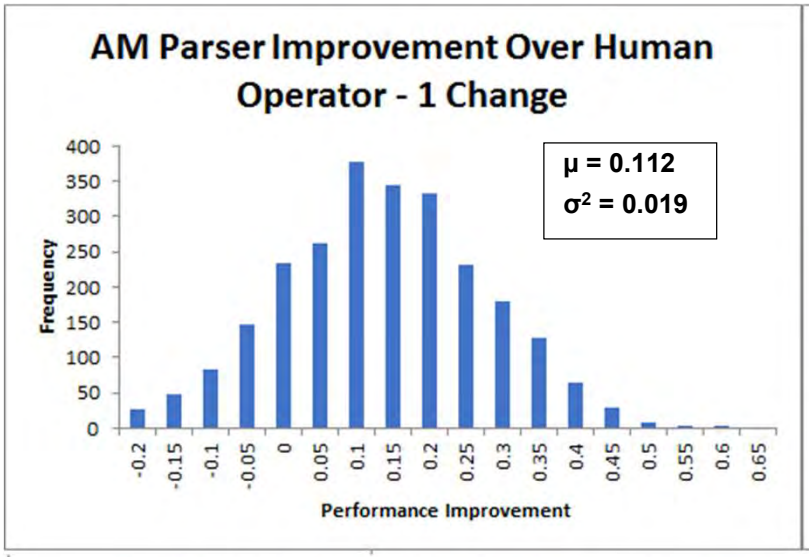


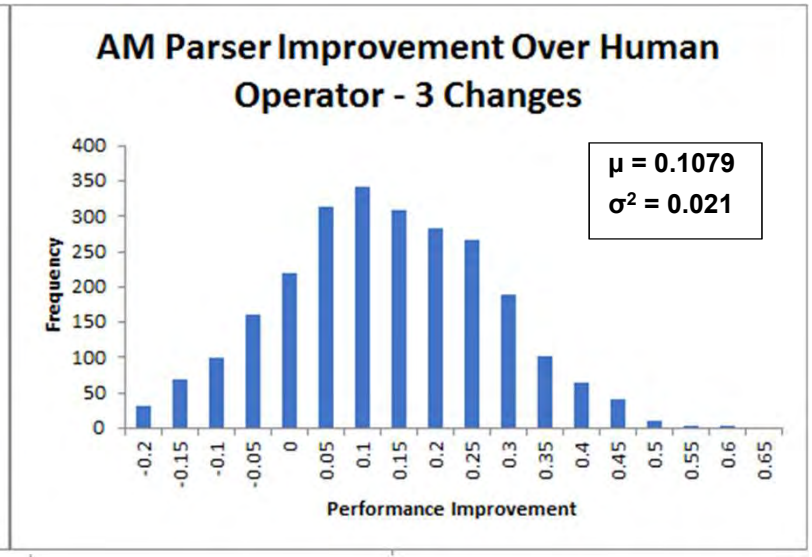


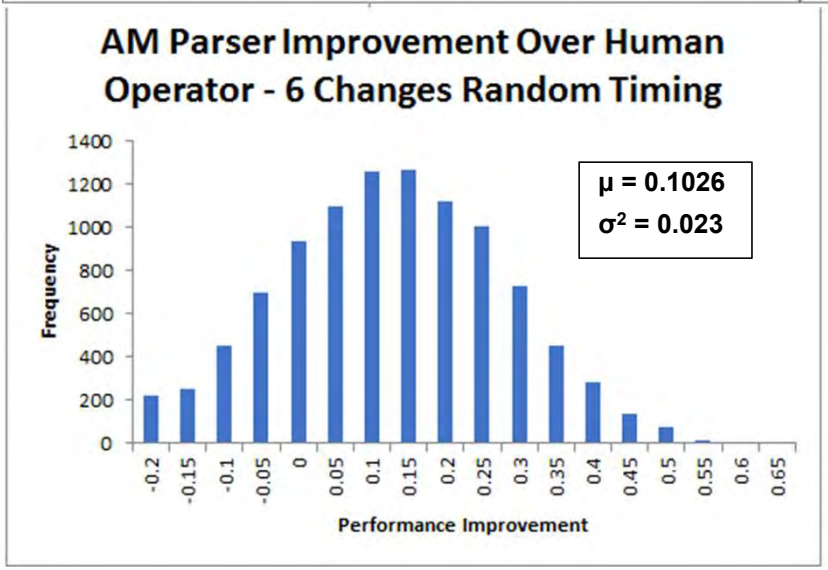
Mean Performance of Optimal and AM Parser

- Stationary: 5.46%
- Nonstationary (1 change): 5.52%
- Nonstationary (3 changes) : 6.12%
- Nonstationary (6 changes) : 7.03%

Nonstationary Performance







Performance Improvement (Δ)

- Stationary: 11.37%
- Nonstationary (1 change): 11.20%
- Nonstationary (3 changes) : 10.79%
- Nonstationary (6 changes) : 10.57%

Conclusions

- Initial simulation shows:
  - Performance improvement
  - Robust to dynamically changing performance conditions
  - Can be improved with more sophisticated models of workload and more flexible performance thresholds

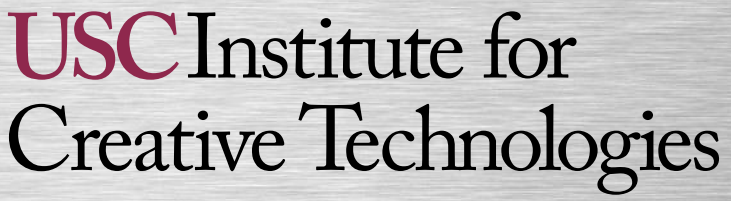
Future Work

- Add more physiological indicators of human workload
- Extend AM beyond static thresholds
  - Physiological & Performance
- Model hierarchical dependences between tasks
  - Single HMT, Teams of HMTS
- Develop task environment
  - Modify AM to real-time parsing of physiological and performance

Questions?

Nonstationary Mean Performance

Nonstationary Summary Statistics						
Condition	Optimal Mean (SD)	AM Parser (SD)	Mean Difference	t	p	Effect Size
Nonstationary (1 Change)	66.81% (11.92%)	61.29% (9.45%)	5.52%	58.16	0.000	0.513
Nonstationary (3 Change)	66.97% (11.99%)	60.85% (6.64%)	6.12%	56.07	0.000	0.631
Nonstationary (6 Change)	67.04% (11.91%)	60.01% (5.63%)	7.03%	57.19	0.000	0.755
Condition	Optimal Mean (SD)	AM Parser (SD)	Mean Difference	t	p	Effect Size
Nonstationary (1 Change)	50.09% (14.53%)	61.29% (9.45%)	11.20%	80.67	0.000	0.914
Nonstationary (3 Change)	50.06% (14.62%)	60.85% (6.64%)	10.79%	74.59	0.000	0.948
Nonstationary (6 Change)	49.75% (14.77%)	60.01% (5.63%)	10.26%	67.63	0.000	0.918



Towards Natural Dialogue with Robots: ARL Bot Language

Presenter: Matthew Marge (ARL)

Co-Authors: David Traum (ICT), Clare R. Voss (ARL), Susan G. Hill (ARL)

Addressing research problems relevant to transitioning robots from *Tools* to *Teammates*

Vision: Natural and intuitive bi-directional communication

- Spoken **dialogue** with mixed initiative

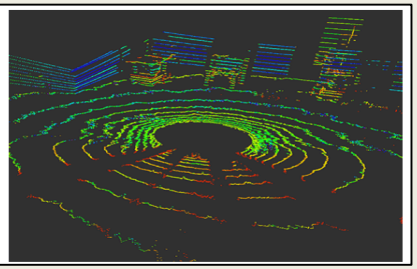
Tool

Teammate

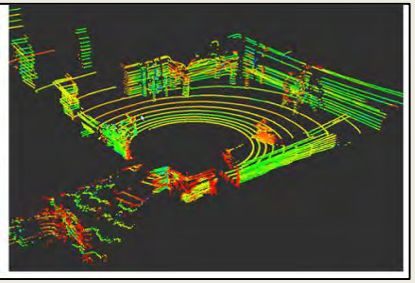
U.S. ARMY RDECOM

Project Objectives

ARL

H: Enter and scan first room

R: I see a door to the right and a door to the left
H: Scan next open room on left

USC Institute for Creative Technologies

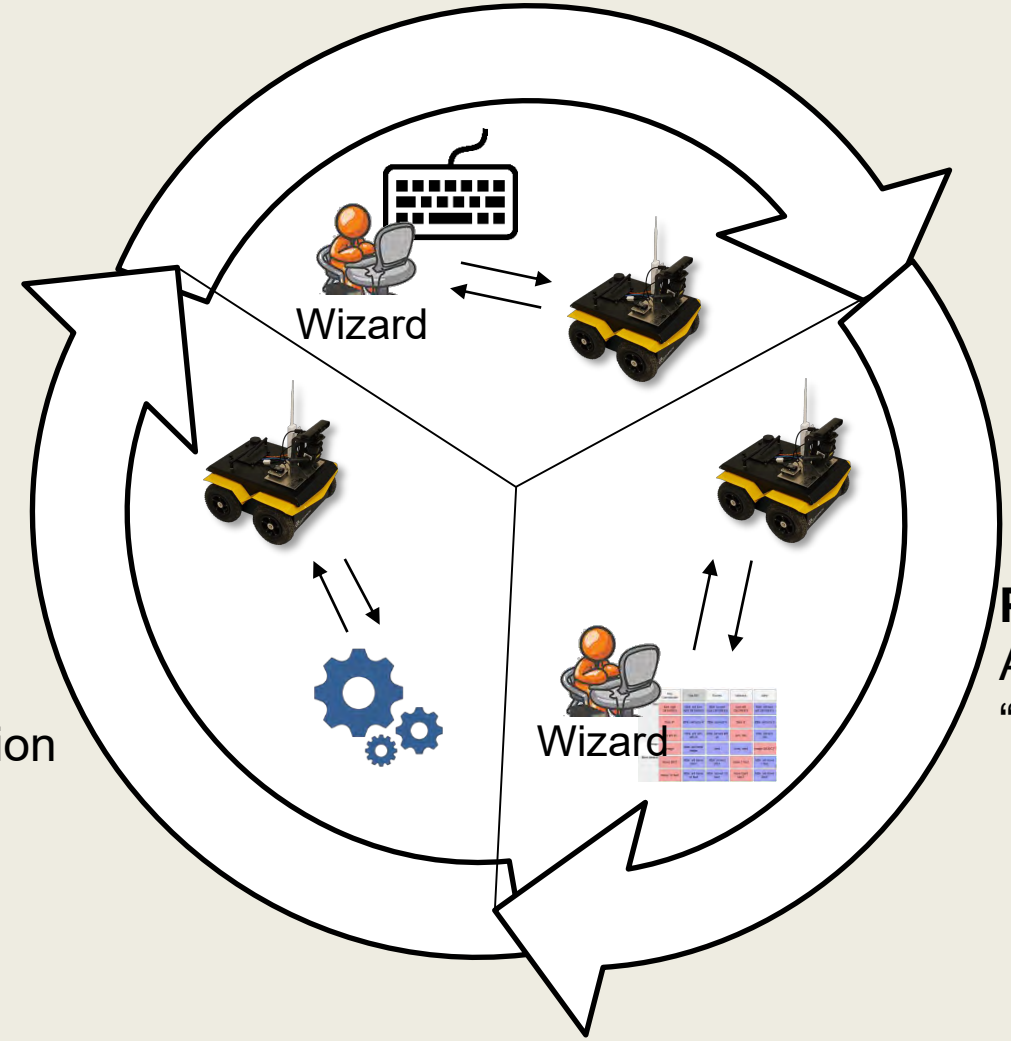
Virtual Human
(DeVault et al., 2014)

- Understand human language use to design robot capabilities needed for effective communication
- Collect data containing natural language commands and associated multimodal data from robot
  - Task: Human "teammate" is engaging in dialogue with robot "teammate"
- Can we successfully leverage dialogue management approaches from Human-Virtual Human (VH) dialogue and apply to robots?
  - Phased "Wizard of Oz" methodology

Team Members
ARL CISD: M. Marge, C. Bonial, C. Hayes, S. Lukin, C. Voss
ARL HRED: S. Hill, A. Evans, A. Foots, K. Pollard
ICT (Army UARC)@USC: D Traum, R Artstein, A Leuski

Bot Language Lifecycle

Phase 1 Exploratory Data Collection



Phase 2
Automate Some
"Wizard" Labor

Phase 3
Full Automation
Of "Wizard"

Lifecycle of Human-Robot Dialogue Development

Phase 1 Exploratory Data Collection

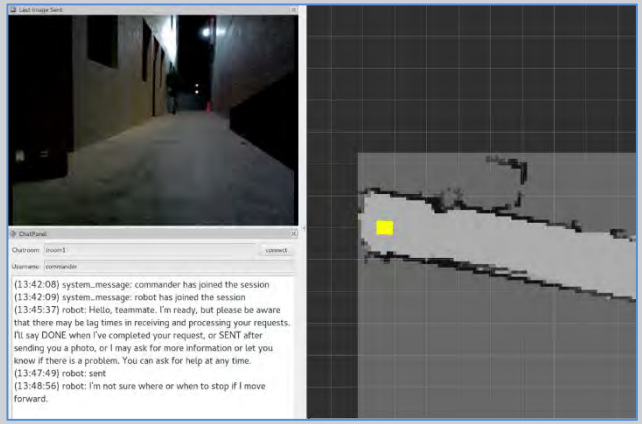
Phase 2
Automate Some
"Wizard" Labor

Phase 3
Full Automation
Of "Wizard"

Approach

Human Commander

VIEWS



VERBAL COMMANDS

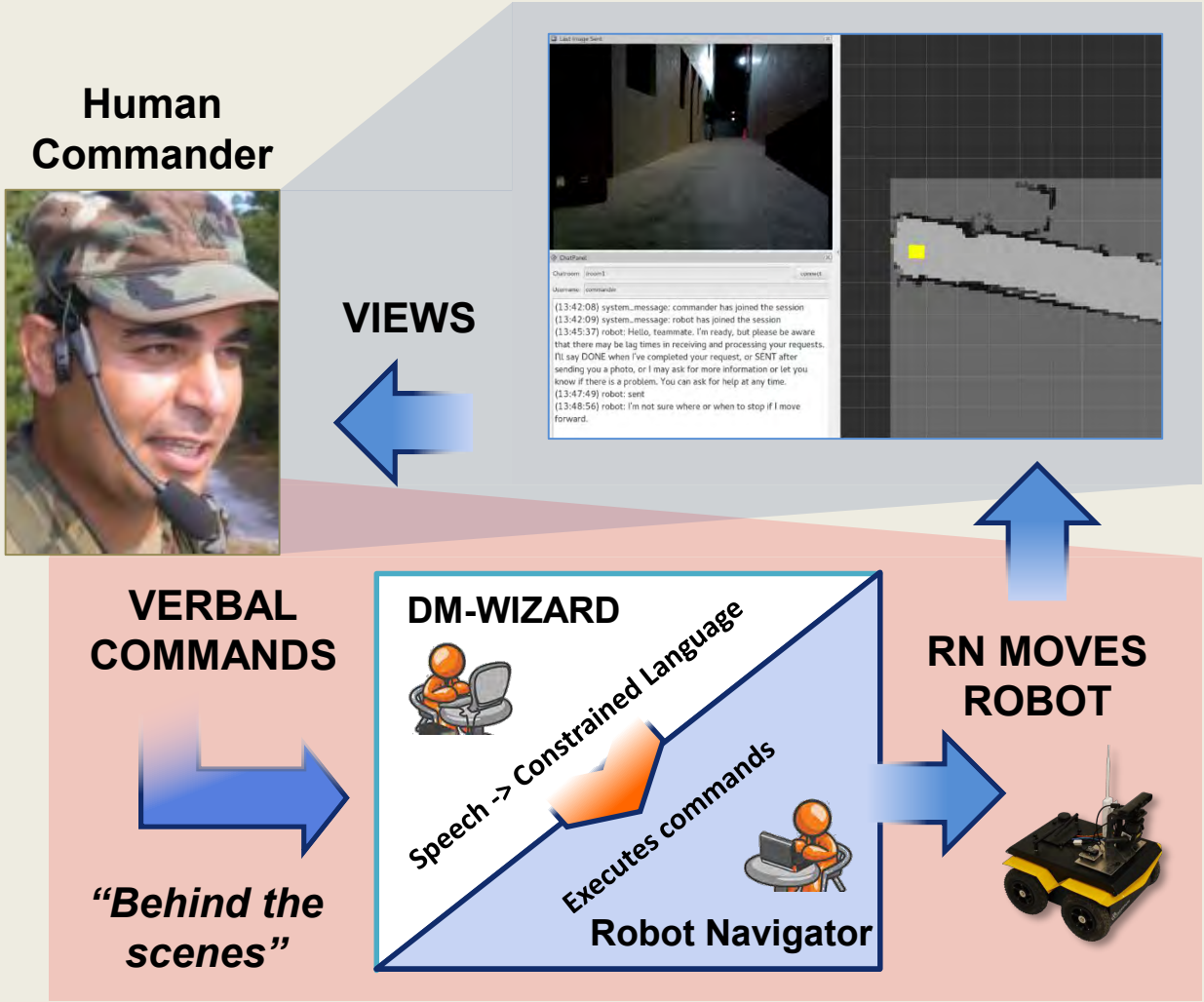
ROBOT (remote from Commander)

(Marge et al., 2016, IEEE RO-MAN)

Approach

- Dialogue Manager (DM-Wizard) is the “brains” of the robot in natural language interactions

- Robot Navigator (experimenter) navigates robot based on instructions from DM-Wizard



Approach

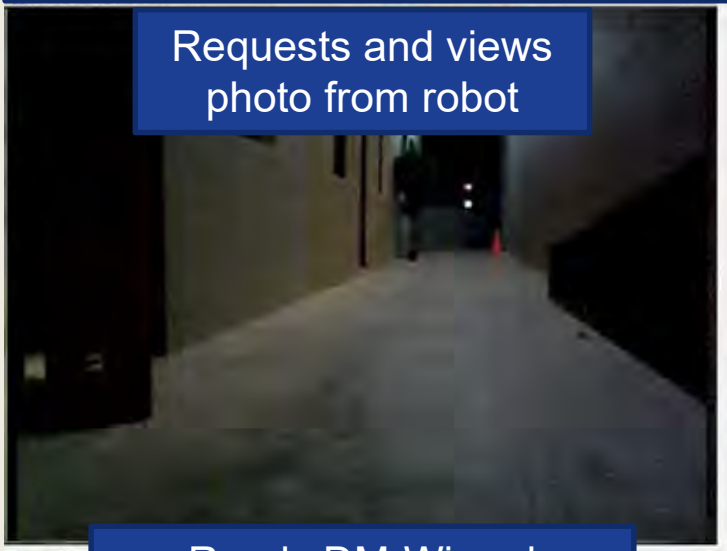
- Dialogue Manager (DM-Wizard) is the “brains” of the robot in natural language interactions

- Robot Navigator (experimenter) navigates robot based on instructions from DM-Wizard

Commander View

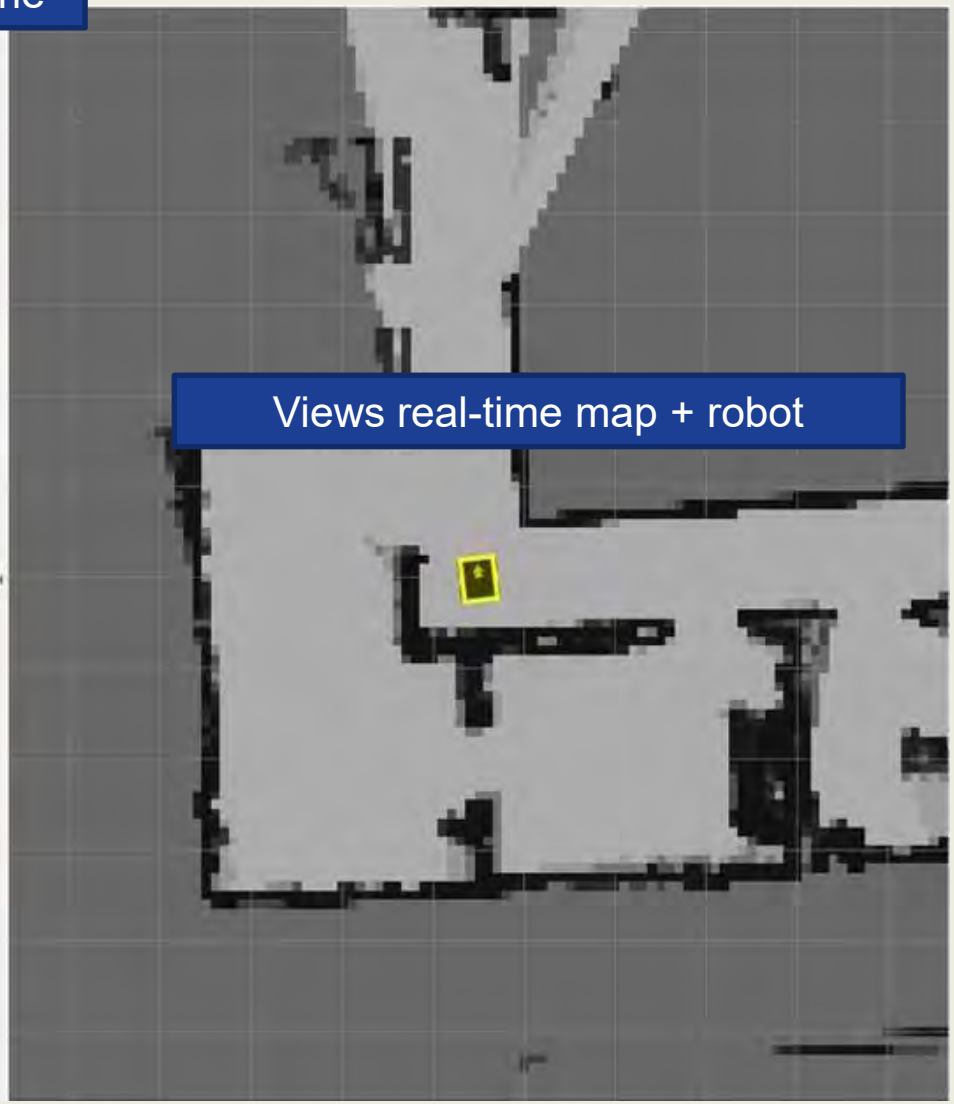
Commander: Speaks into microphone

Requests and views photo from robot



Reads DM-Wizard dialogue responses

Views real-time map + robot

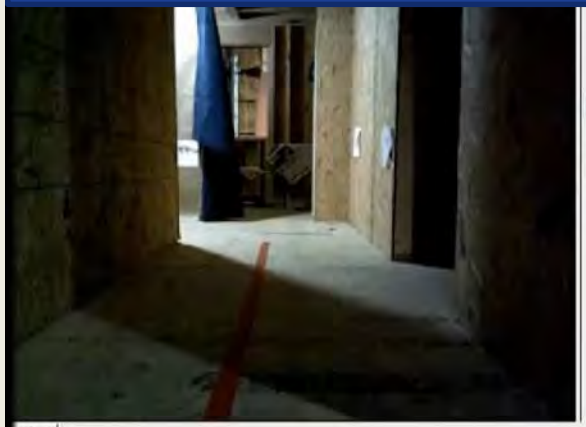


DM-Wizard View: Experiment 1

Dialogue Manager: Listens to Commander via headphones

Views video from robot

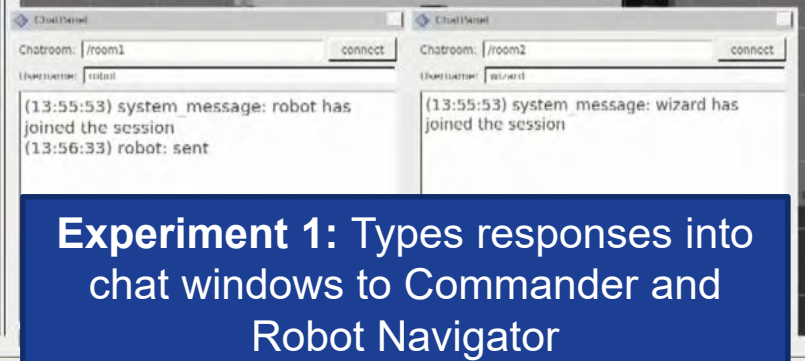
Views photo sent to Commander



Views real-time map + robot

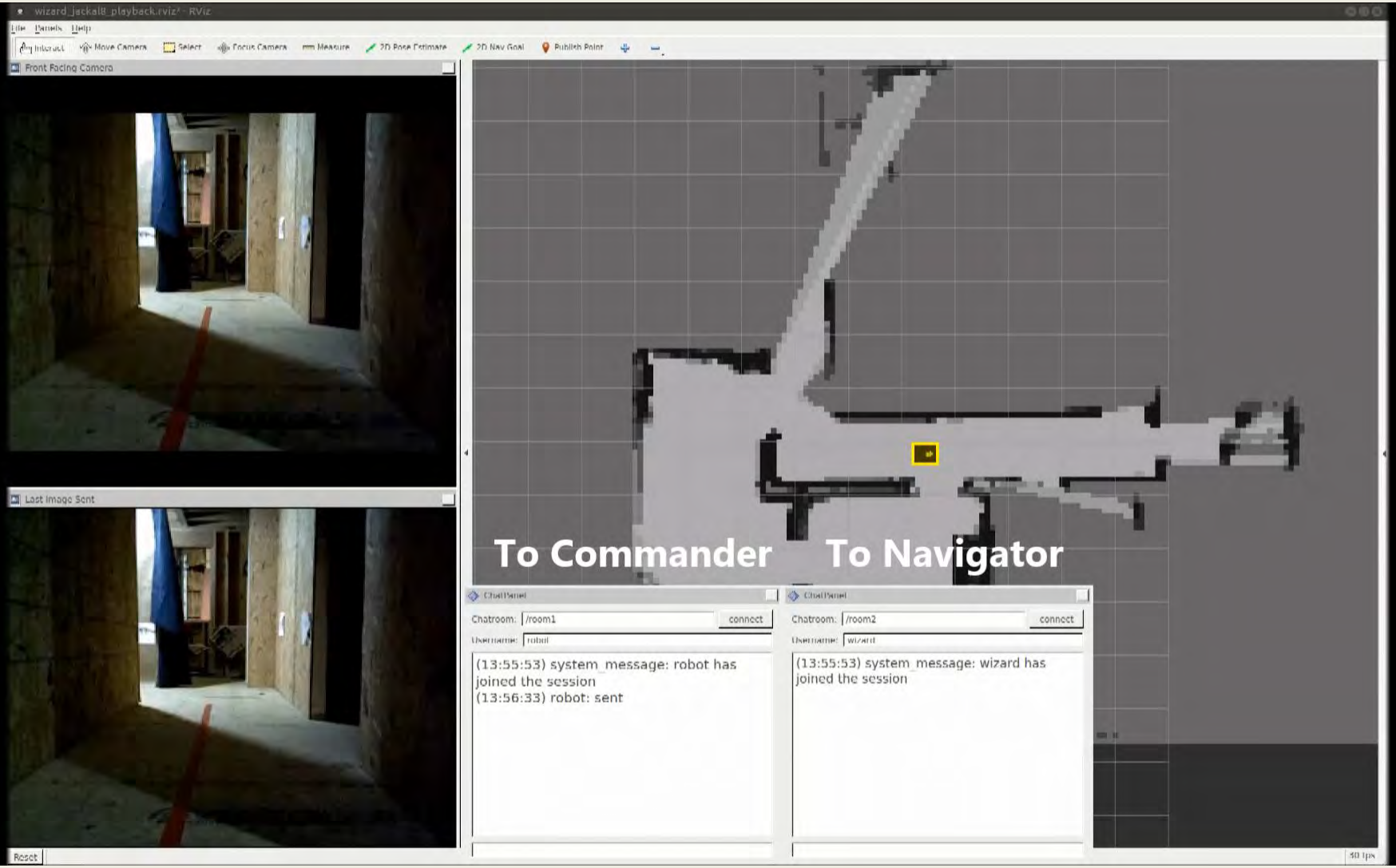
To Commander

To Navigator



Experiment 1: Types responses into chat windows to Commander and Robot Navigator

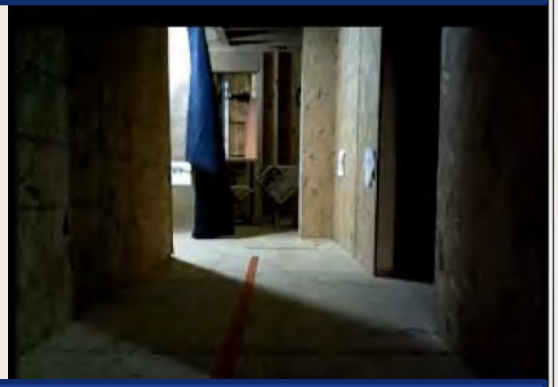
Video: DM-Wizard in Experiment 1



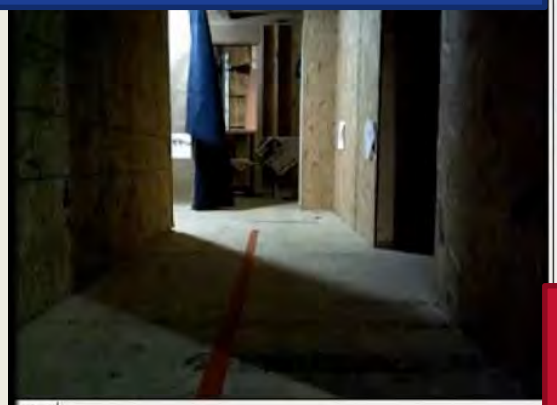
DM-Wizard View: Experiment 2

Dialogue Manager: Listens to Commander via headphones

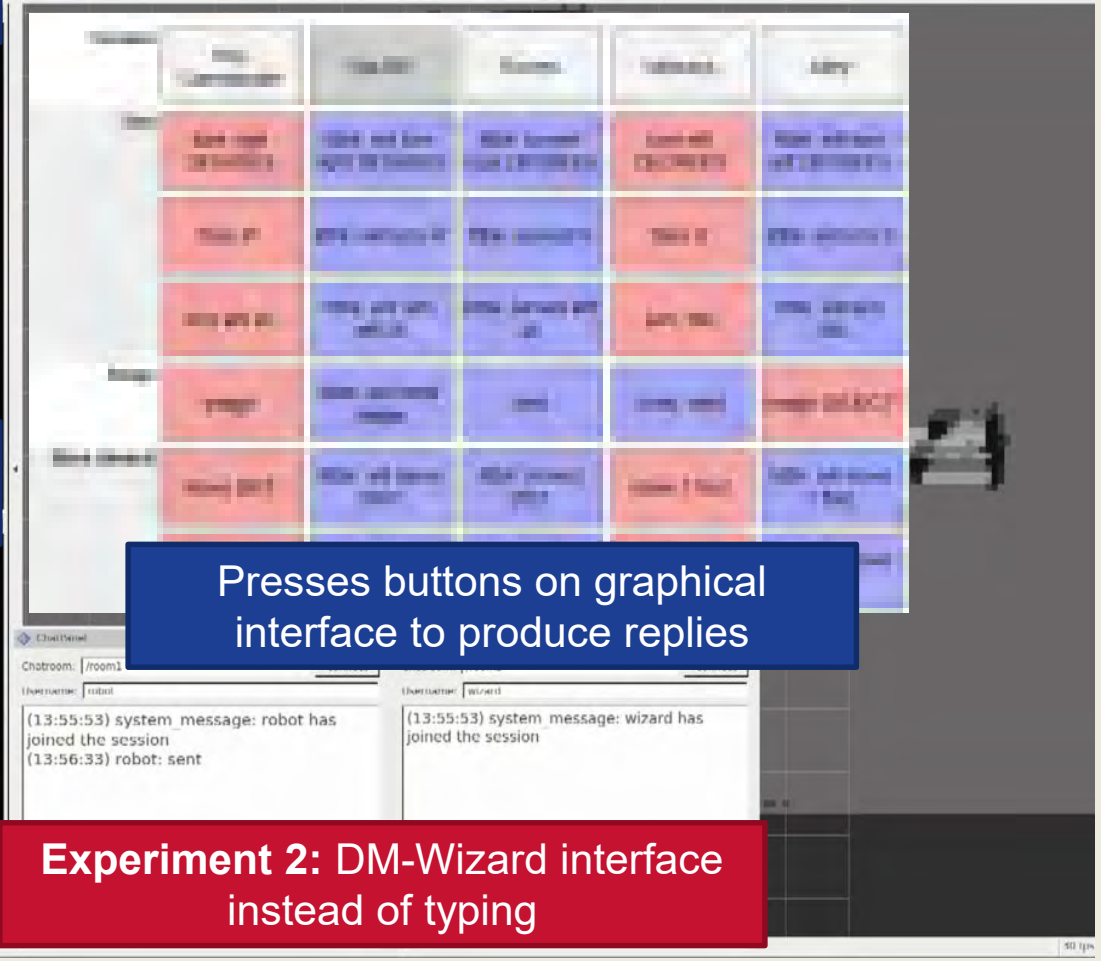
Views video from robot



Views photo sent to Commander

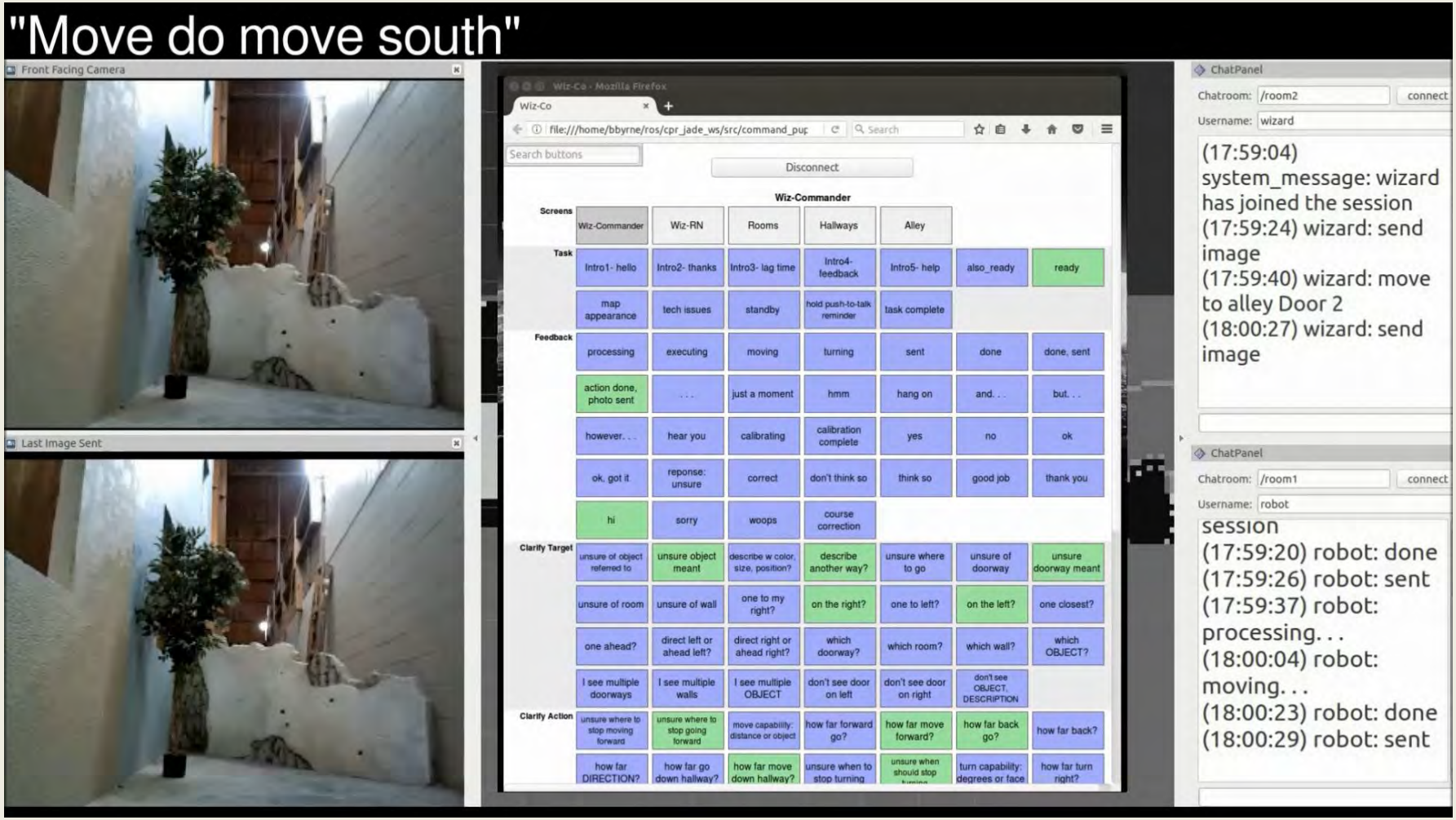


Presses buttons on graphical interface to produce replies



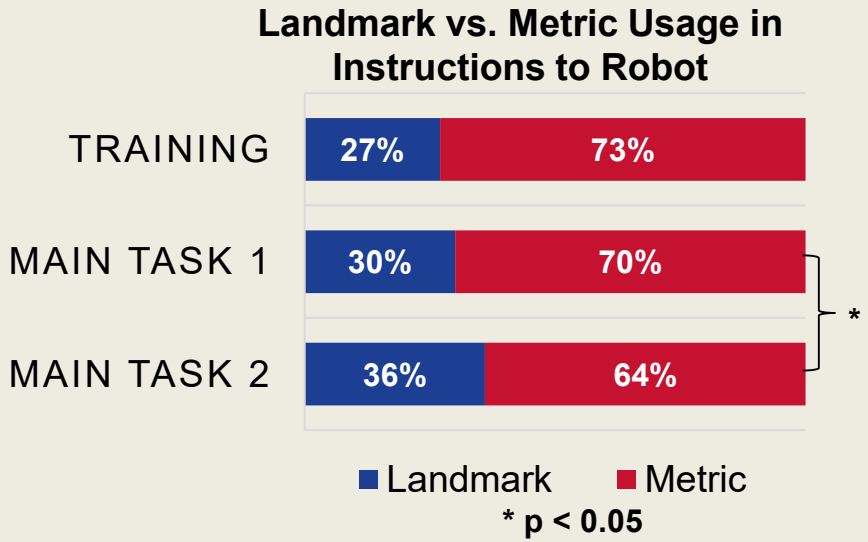
Experiment 2: DM-Wizard interface instead of typing

Video: DM-Wizard in Experiment 2

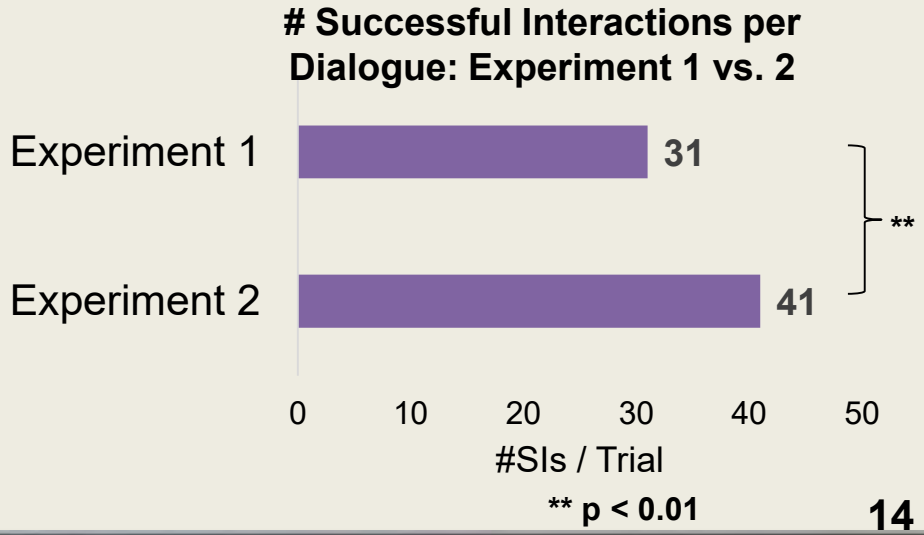


Results from Experiments 1 & 2

- **Experiment 1:** People use a variety of language when interacting with robots

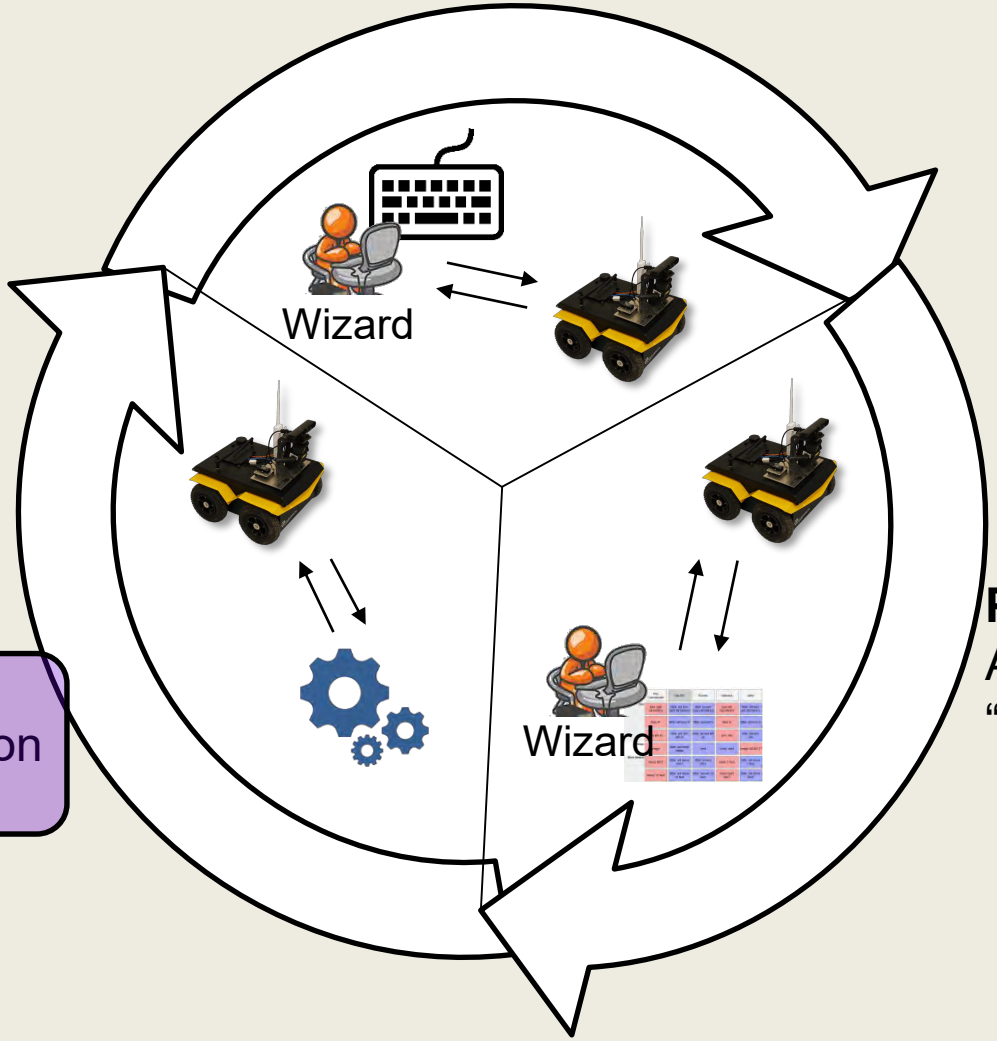


- **Experiment 2:** DM-Wizard GUI improves data collection by enabling faster data collection (more successful interactions)



Lifecycle of Human-Robot Dialogue Development

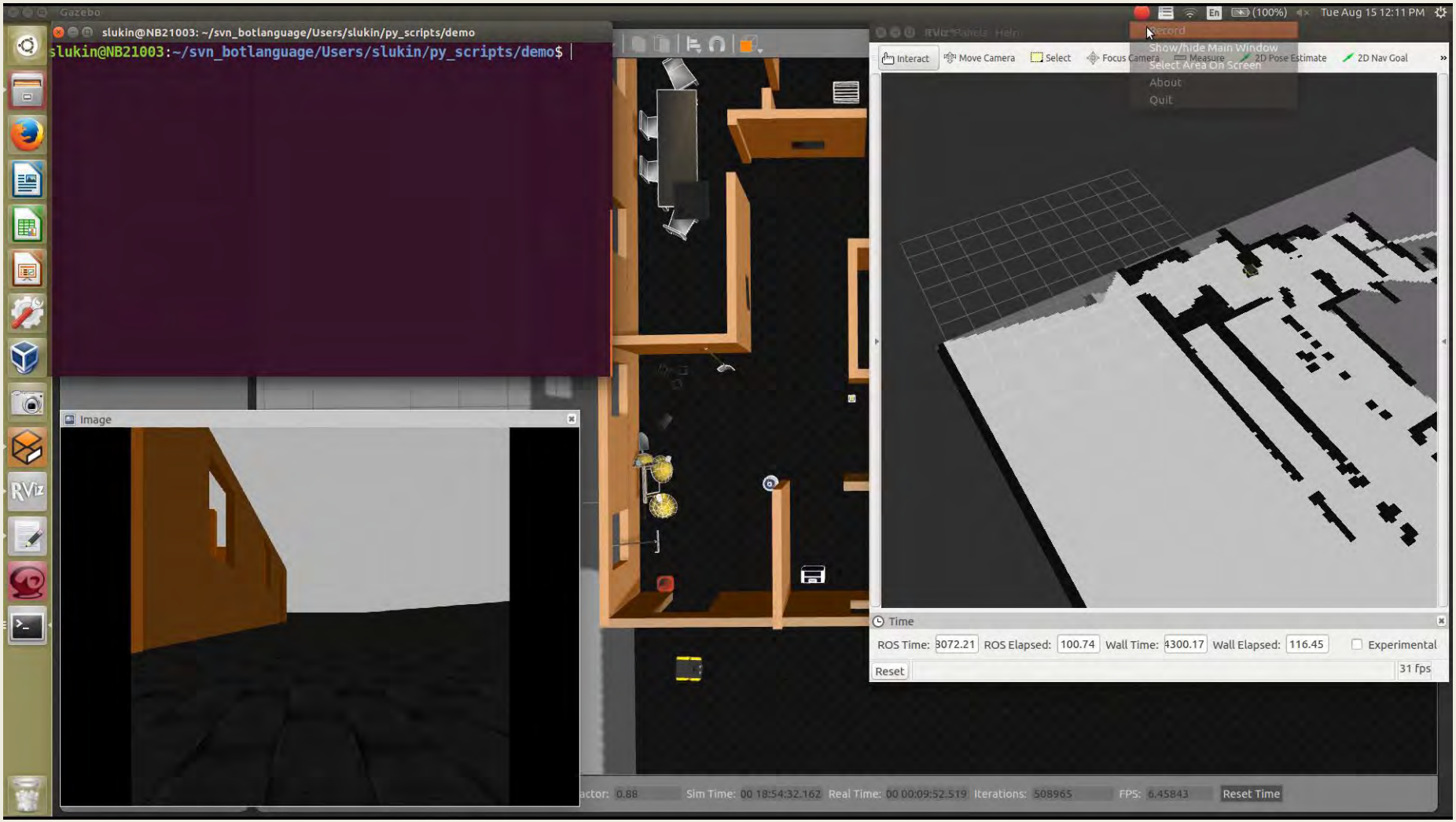
Phase 1 Exploratory Data Collection



Phase 2
Automate Some
"Wizard" Labor

Phase 3
Full Automation
Of "Wizard"

End Goal: Autonomous Dialogue Manager



Summary

Research Goal: Studying humans having natural dialogues with robots

- Contributes to natural language & multimodal training data between humans and robots
- Dialogue offers humans a way to supplement a robot's knowledge / understanding of the world
- Evaluating ability to leverage work conducted for virtual humans and apply to robots
- Identifying concepts critical to human-robot dialogue

Natural language control

Sgt. Blackwell
Virtual Human
Developed at ICT

Thank You!

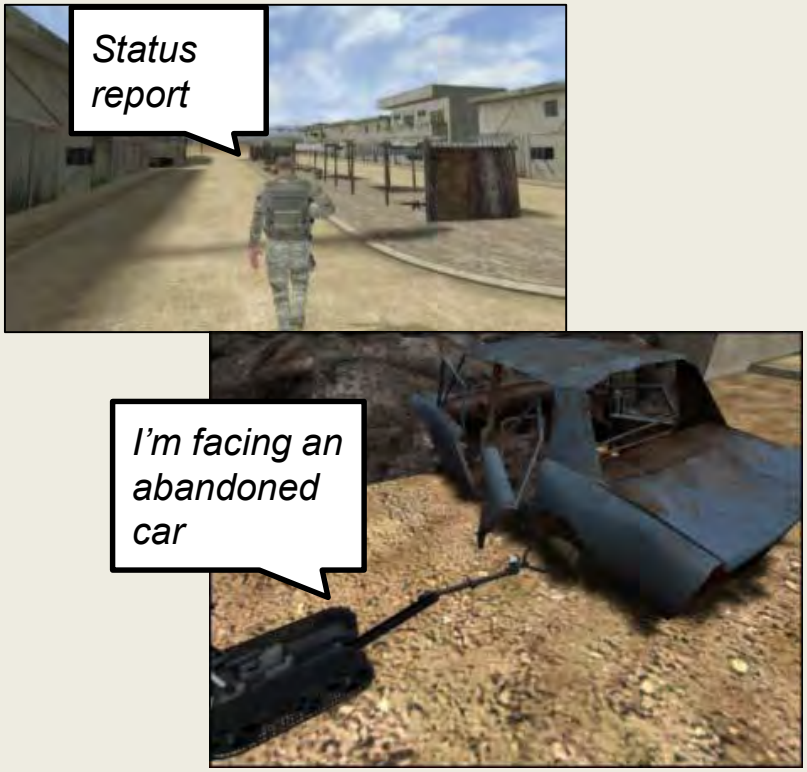
Motivation

Challenges

How is language used in dialogue with technology (vs. human-human dialogue)?

What will robot need to "know" and "see" in order to have common ground with humans?

Army-unique issues include operational environment and tempo, vocabulary, non-structured environment



Current State of the Art

Robot has limited understanding of navigation and manipulation commands; no dialogue, only simple one-way replies

Series of studies planned that will examine:

- » Increased automation support for dialogue management
- » Multimodal inputs (e.g., head nods, eye gaze)
- » Human-robot dialogue in more complex environments

-Natural interaction to enhance situation awareness
-Simplified control of robotic partners
-Reduced cognitive load

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Open Campus Initiative

ARL

Past: Current Defense Laboratory Model

Gates and high walls provide 20th century security, but are barriers to 21st century innovation

Defense laboratories relatively unchanged since inception (NRL 1923)

Present & Future: Open Campus Initiative

Reduction in barriers to facilitate collaboration with academia, industry, and small business

Less bureaucracy and paperwork

Open areas for researchers and access to existing facilities

Collaboration between ARL and external scientists

Career path for students and scientists

Hub and Spoke Model

Collaborator presence through EUL

Novel staff opportunities

An enhanced defense research environment that fosters discovery and innovation through collaboration on fundamental research

Realizing Our Collective Vision by 2025: Leveraging advances in Artificial Intelligence and Autonomy with Human Systems in Human-Machine Symbiosis to Realize Our Roadmap to the Future …

a Cyber-Security Workforce Use Case

Dylan Schmorrow, PhD, *Chief Scientist & Executive Vice President*

Denise Nicholson, PhD, *VP of Intelligent Training & Director of "X"*

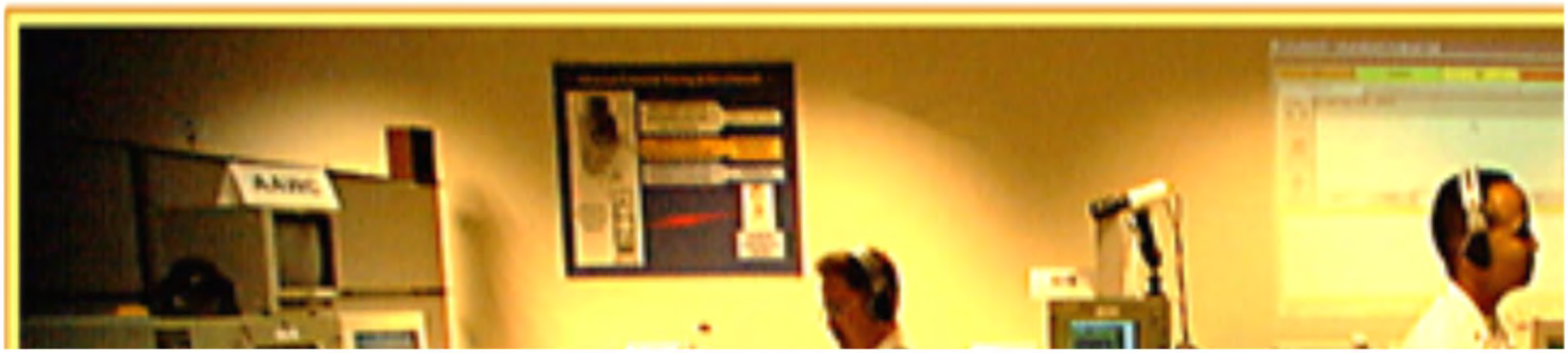
SOARTECH

Modeling human reasoning.
Enhancing human performance.

Outline

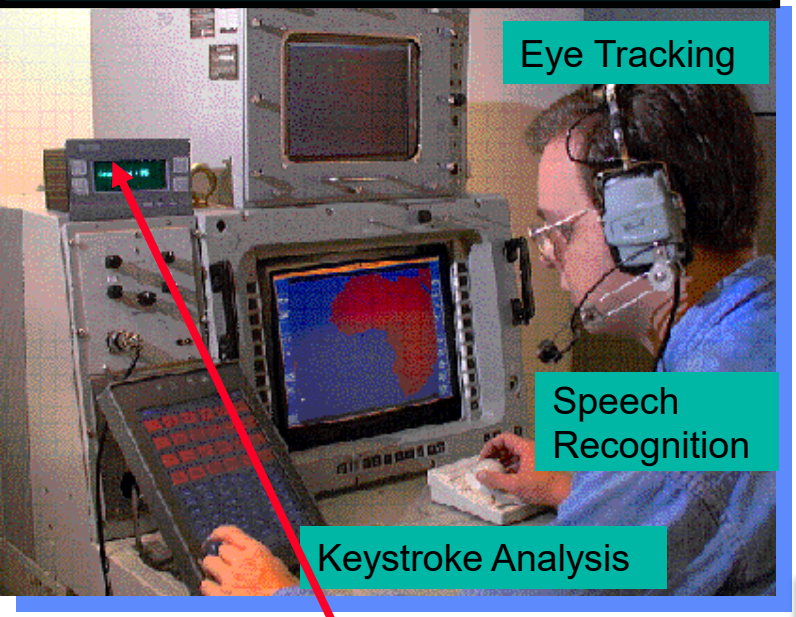
- Where have we come from
  - Early concepts in Advanced Embedded Training
- Where are we going
  - Personalized, Life Long Learning
  - Sailor 2025 – Ready Relevant Learning
- A Use Case in Cyber Workforce Training
  - National Initiative for Cybersecurity Careers and Studies (NICCS) Framework
  - Training Learning Architecture in conjunction with LVC learning experiences
- Challenges for 2025
  - Data Data Data

1998 ACTD
Advanced Embedded Training System



1998 ACTD
Advanced Embedded Training System

Student Model: Measured Operator Actions



Expected Operator Actions Generated By **Expert Models**

Comparator
Automated Performance Assessment Engine

Training Mitigation Director
Operator Action Evaluations Focused on Scenario Key and Critical Events

Online Feedback

Diagnosis of Knowledge And Skill Deficiencies

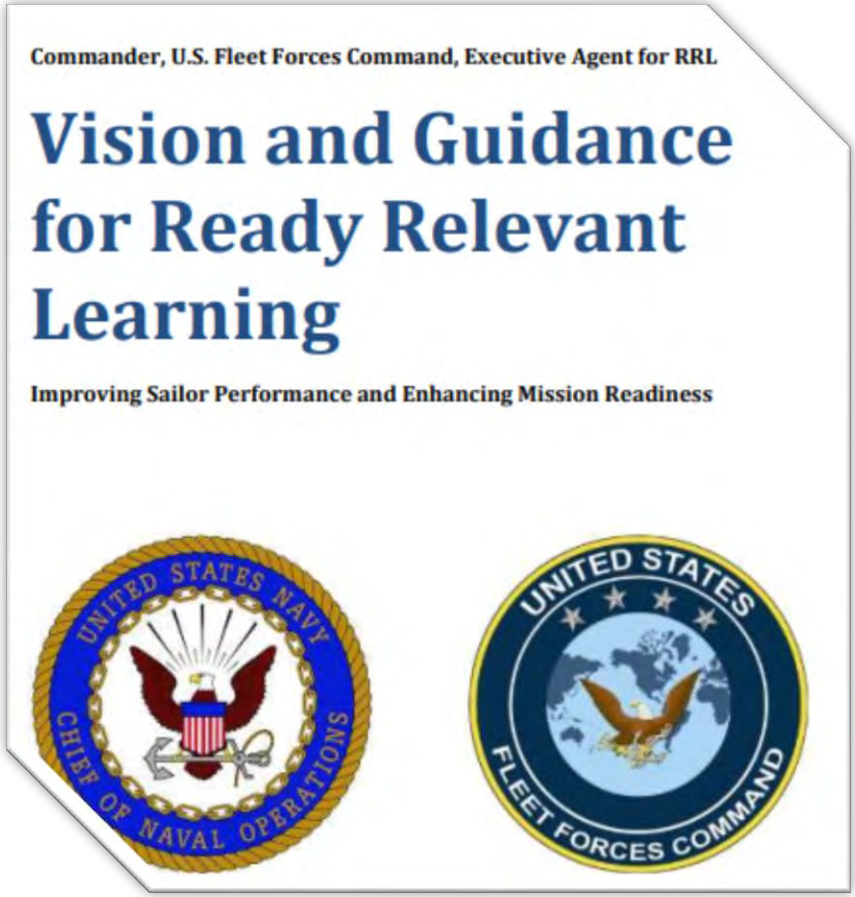
Post-Exercise Debriefing

Instructor Hand-Held Device ShipMATE

- Performance Measurement Subsystem – LM ATL & TSD
- Diagnostic Subsystem – CHI Systems, Aptima & TSD
- Instructional Subsystem – Sonalysts & TSD

Sailor 2025 – 3 Key Elements of RRL

1. Career- Long Learning Continuum
2. Modern delivery at the point of need
3. Integrated Content Development
   - Delivery methodologies

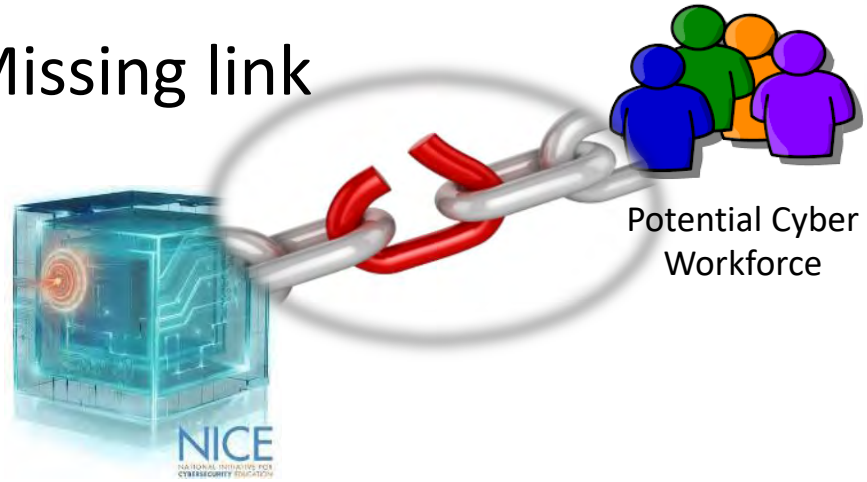


http://www.public.navy.mil/usff/rrl/Documents/PDFs/rrl-vision-and-guidance-final.pdf

NDIA HUMAN SYSTEMS

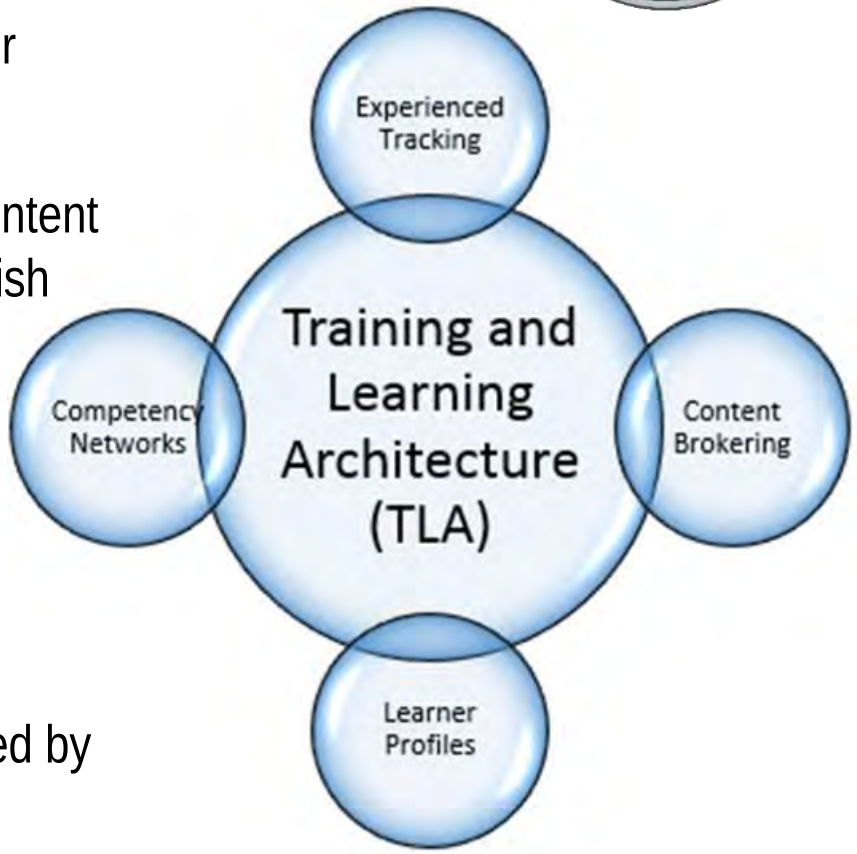
USE CASE - National Initiative for Cybersecurity Careers and Studies (NICCS)

- Shortage in cyber security workforce
- Aid in pinpointing what current and future professionals need to know for a career in the cyber workforce
- Missing link

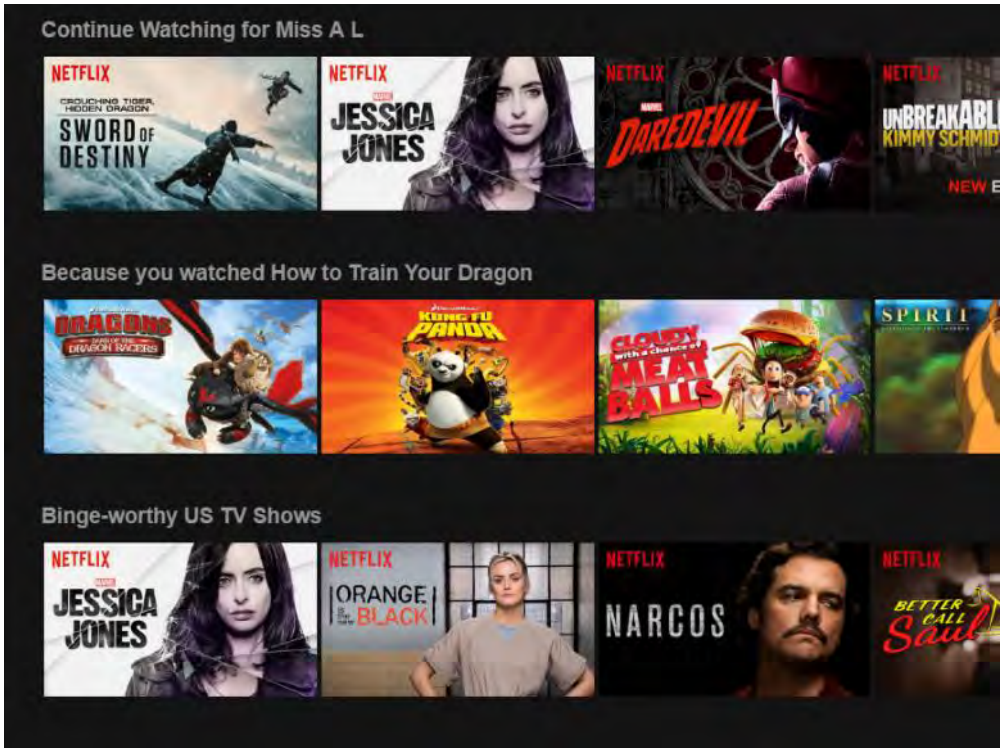


Training and Learning Architecture (TLA)

- Learner Profiles
  - Basic information regarding the user
- Content Brokering
  - Decision making on what type of content the user needs to cover to accomplish their unique goal
- Experience Tracking
  - Learner profiles updated as learner progresses in competency
- Competency Network
  - Library of course content to be pulled by content brokering as needed

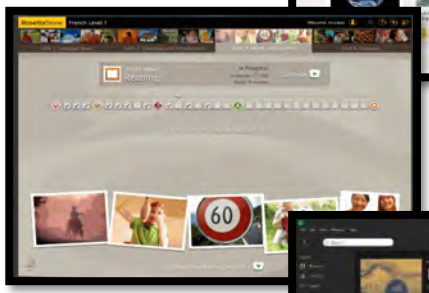


Recommender UI
Our metaphor: multiple offerings and rationales




Roadmap


Social Media


Album

Playlist

Alternate / future UIs →

Use Case with TLA

Career Goals

Recommendation:
LVC Exercise with AI Red team

KSA #3 - Computer Network Defense & Assessment Tools

Recommendation:
Cyber Mindset Training

KSA #2 - Adversary Tactics, Techniques, & Procedures

Recommendation:
CYSTINE Simulation

KSA #1 - Insider Threat

NICCS Framework

Recommendation:
SCITE 3D Game

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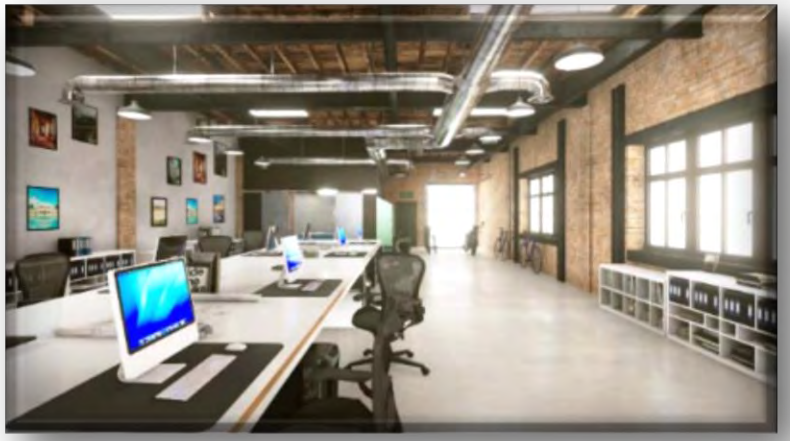
KSA #1: Knowledge of and experience in Insider Threat

Recommended Activity: 3D Insider Threat Game

- Scenario based gaming environment to experience insider threats
- Occurs within an office space and designed to replicate the exploitation of computer systems by employees to gain access to financial information without permission



UCF

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Enhancing human performance.

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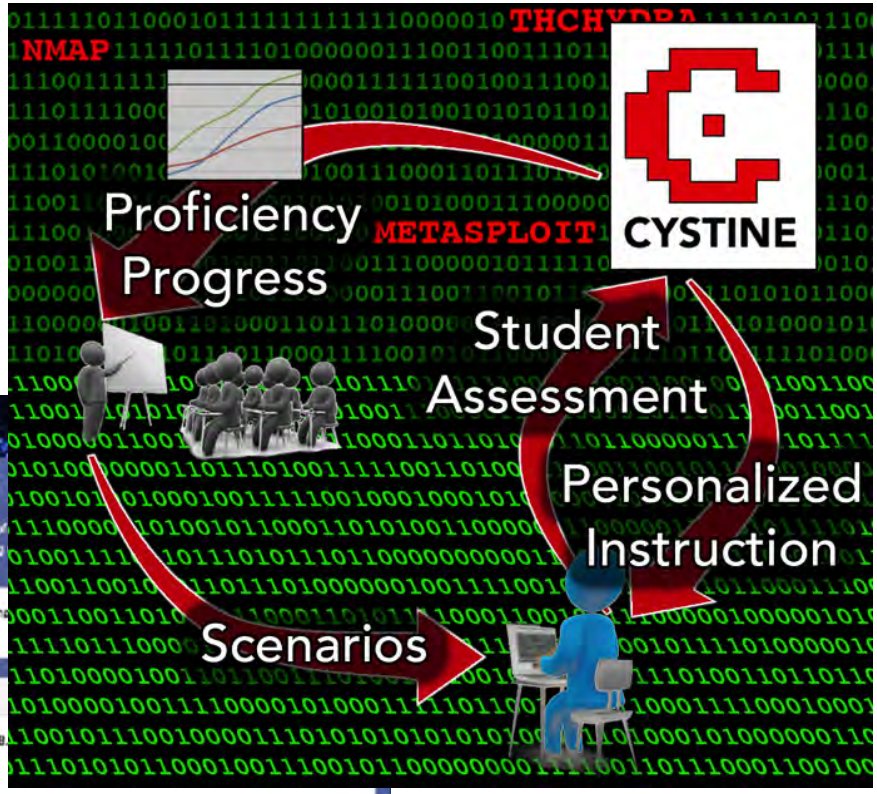
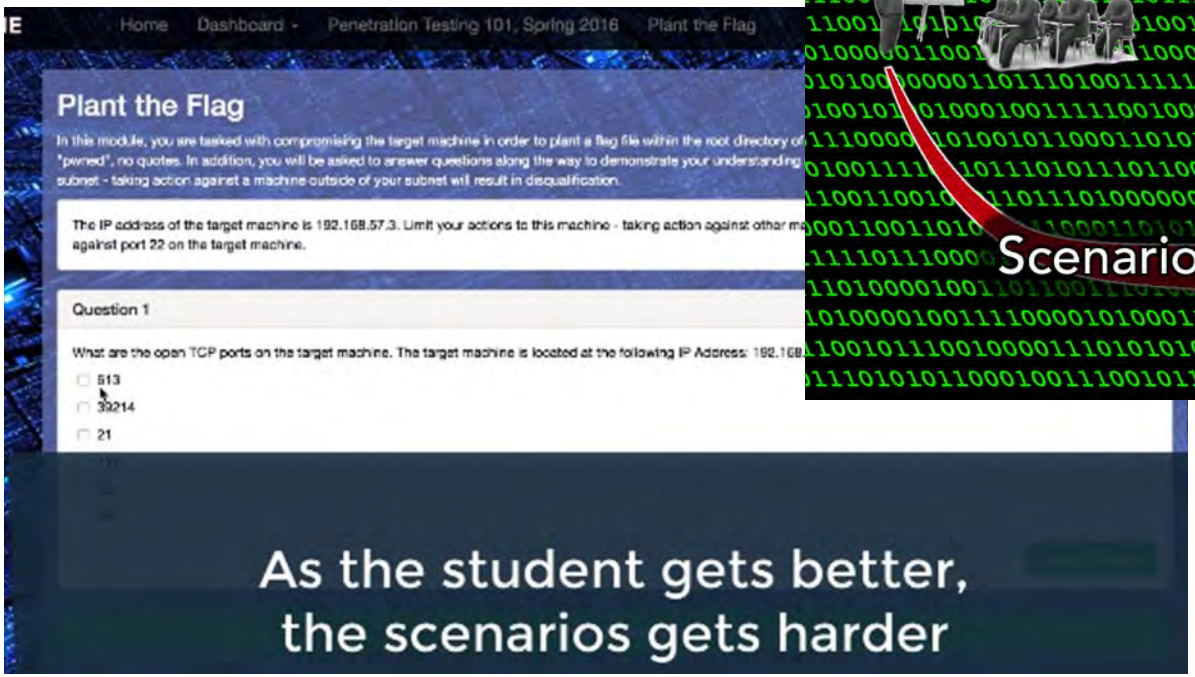
KSA #2: Familiarization w/ Common Adversary Tactics, Techniques, and Procedures

Recommend: Cyber Security Environment (CYSTINE)

- Dynamic training scenario that adapts to the skill of the trainee
- Cyber defender cognitive agents, provide dynamic, cognitively realistic adversaries



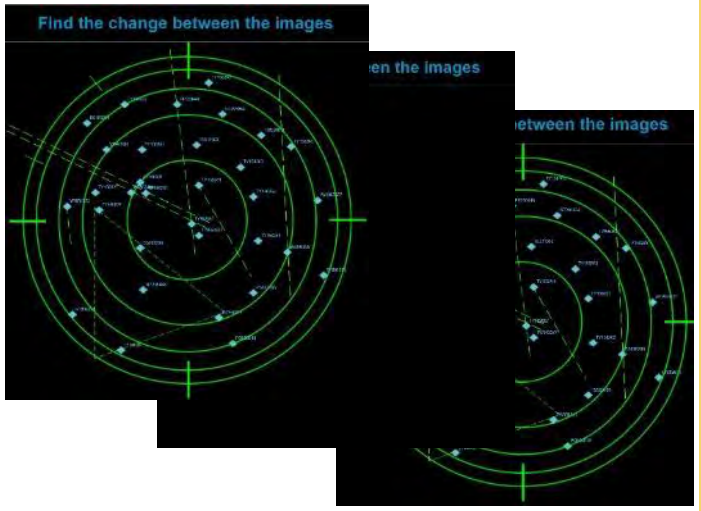


KSA #3: Knowledge of Computer Network Defense Recommendation - Cyber Mindset Training

Cyber basics: Prepare non-cyber personnel to participate in largescale synthetic cyber training

- **Interactive instruction on how to minimize cognitive bias interference**
  - **Challenge assumptions** about immunity to, e.g.,
    - Attentional tunneling
    - In-attentional blindness
    - Confirmation bias
- **Game-based event recognition practice**
  - Develop **perceptual sensitivity**
  - Gain appreciation for importance of maintaining **system awareness**

In-attentional Blindness Exercise:



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KSA #3: Knowledge of Computer Network Defense and Vulnerability Assessment Tools Recommend – LVC Exercise with AI Red Team

Simulated Cognitive Cyber Red-team Attack Model SC2RAM allows training exercises to be implemented on a scale that adaptable to the emerging professionals

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Future Challenges – Data, Data, Data …..

Data

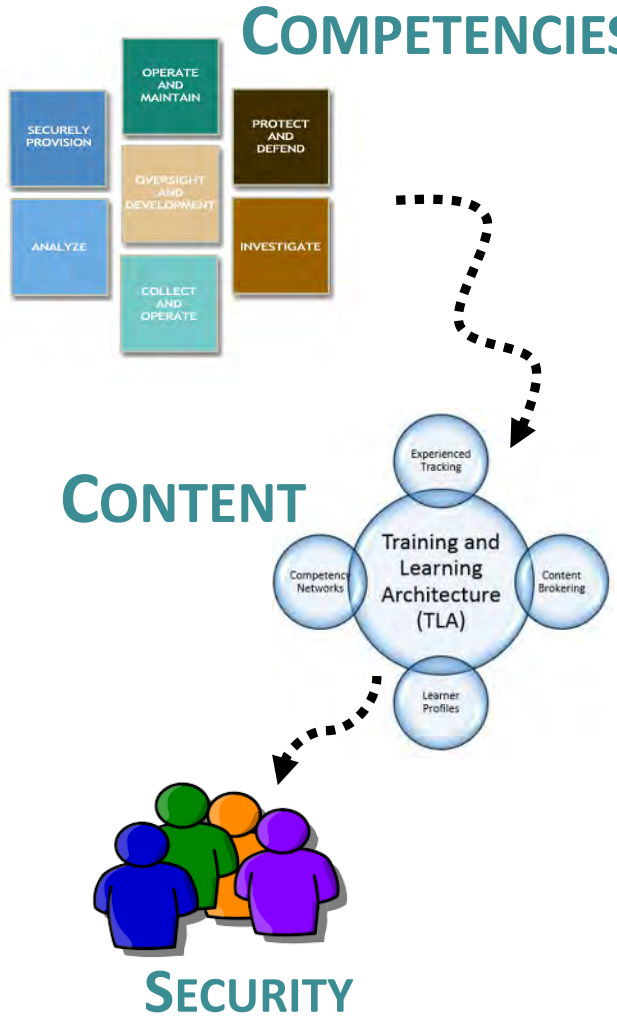
- About the activities/training
  - –Learner progress thru the activity
- About existing content – reuse

Data

- Competencies
  - – Personal Qualification Standards
- Learner models
  - –thru the activity not just complete

Data

- Security & IA
  - – Readiness, Personal data protection



QUESTIONS and DISCUSSION

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Denise Nicholson

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Human-System Metrics Applied to Optimize AF Warfighter Capability

13 March 2018

Integrity ★ Service ★ Excellence

NDIA Human Systems Conference
Ms. Sarah Orr
Human Systems Integration Directorate
711th Human Performance Wing

Overview

- 711 HPW/HP - AF HSI Analysts
  - Providing support across AF
  - Other/joint efforts
- HSI -related requirement activities
  - During early system concept development
  - Throughout the product lifecycle
  - Human-System Requirements
    - ✓ Methodology
    - ✓ Measures and Verification
    - ✓ Metrics
- Example: application of HSI-related requirements in emerging domains: autonomy, human augmentation, and cyber

Human Systems Integration Directorate
711HPW/HP

Mission

Optimize warfighter capability through a human-centric approach to system development, acquisition, and sustainment

HSI Analysts

Optimize total system performance

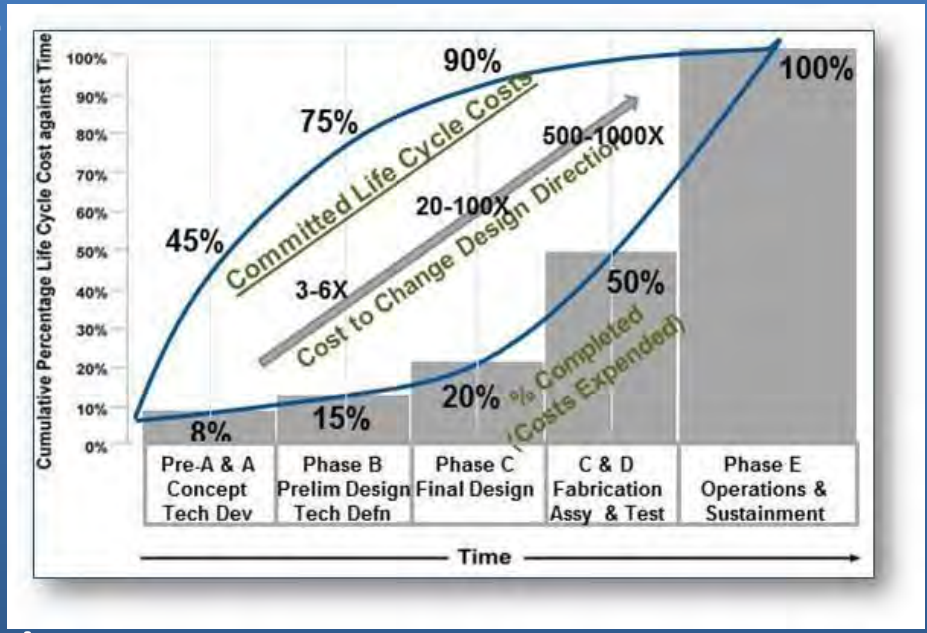
…the relative and combined performance

…human + software + hardware

…trade offs

Optimize total life cycle costs

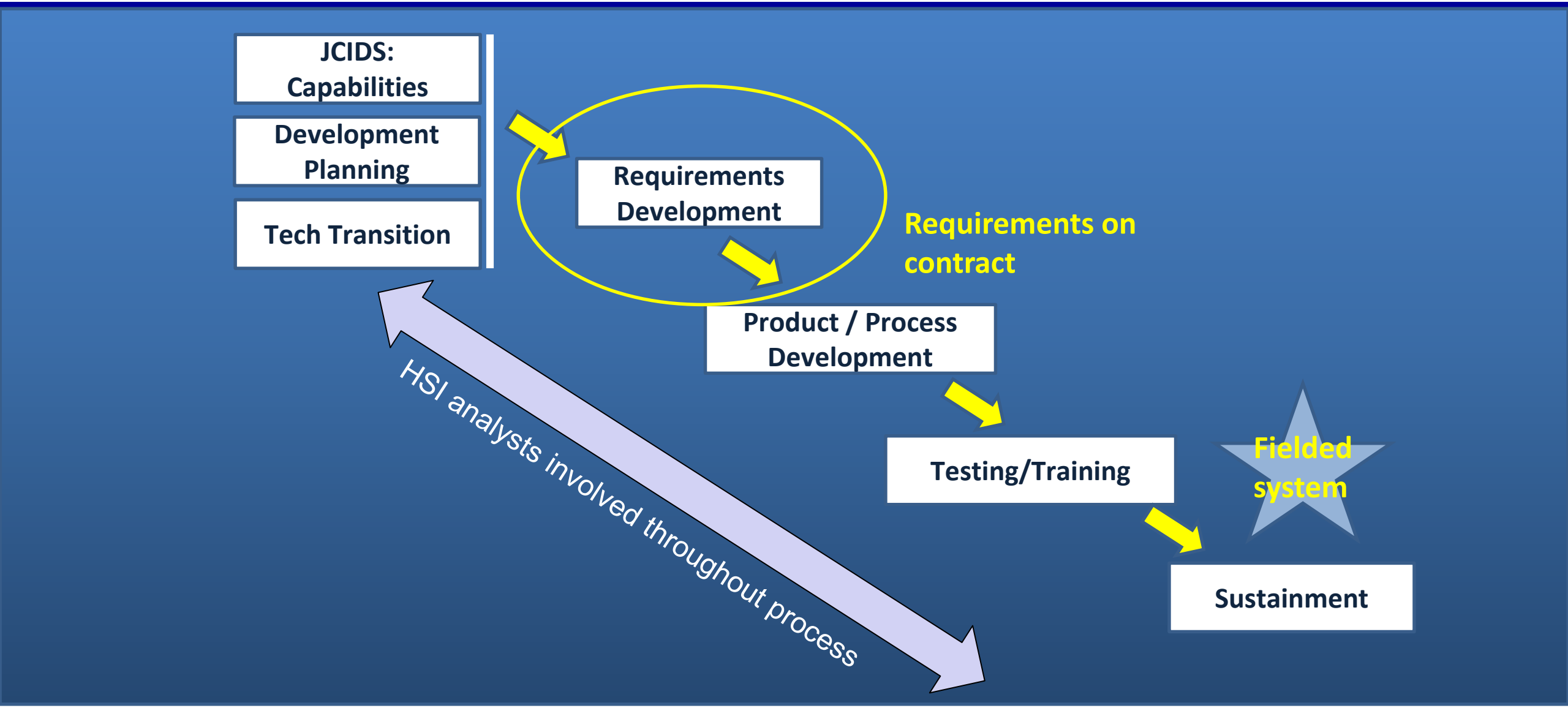
…projecting sustainment costs over 30-70 years (adds up)!



Enable the users to effectively complete the mission

HSI analysts work to ultimately reduce overall program risk

HSI – the Means



Human-System Requirements

System level HSI-related requirements:

- Are performance based. “A performance-based requirement states ‘how well’ a function must be performed. The performance is usually indicated by a measurable value.”

  Source: USAF HSI in the SRD Guidebook, SURVIAC, 2012

- Are accompanied by verification methodology

- Are often accompanied by SOW tasking for associated analyses, modeling and sim, and formative evaluations

Human-System Requirements

Measures versus Metrics:

- Measure is used here for more concrete attributes
- Metric is higher-level; a standard of measurement
- “Metrics can be used to benchmark and measure performance against. Metrics are measures collected over time for the purpose of seeing trends and forecasting program progress to plan.”
  - DAG Chapter 3

Human-System Requirements

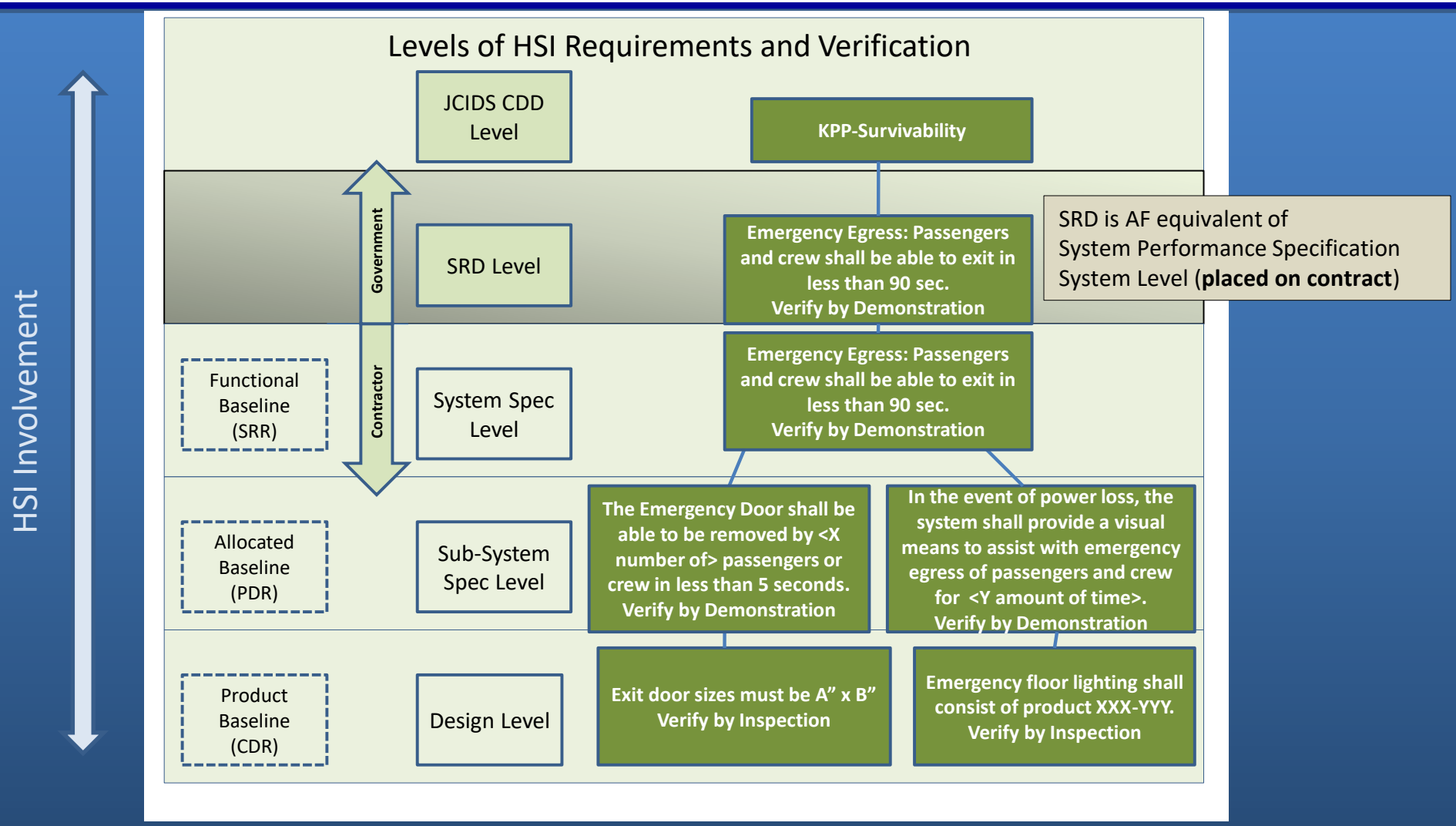
Basic Requirement Statement:

<System D> shall provide <F> feedback within <E> seconds.

Measure: a clear and measureable pass / fail criterion

Source: USAF HSI in the SRD Guidebook, SURVIAC, 2012

Levels of Requirements



JCIDS = Joint Capabilities Integration and Development System; SRR = System Requirement Review; PDR = Preliminary Design Review; CDR = Critical Design Review.
Source: USAF HSI in the SRD Guidebook, SURVIAC, 2012

Requirements Development

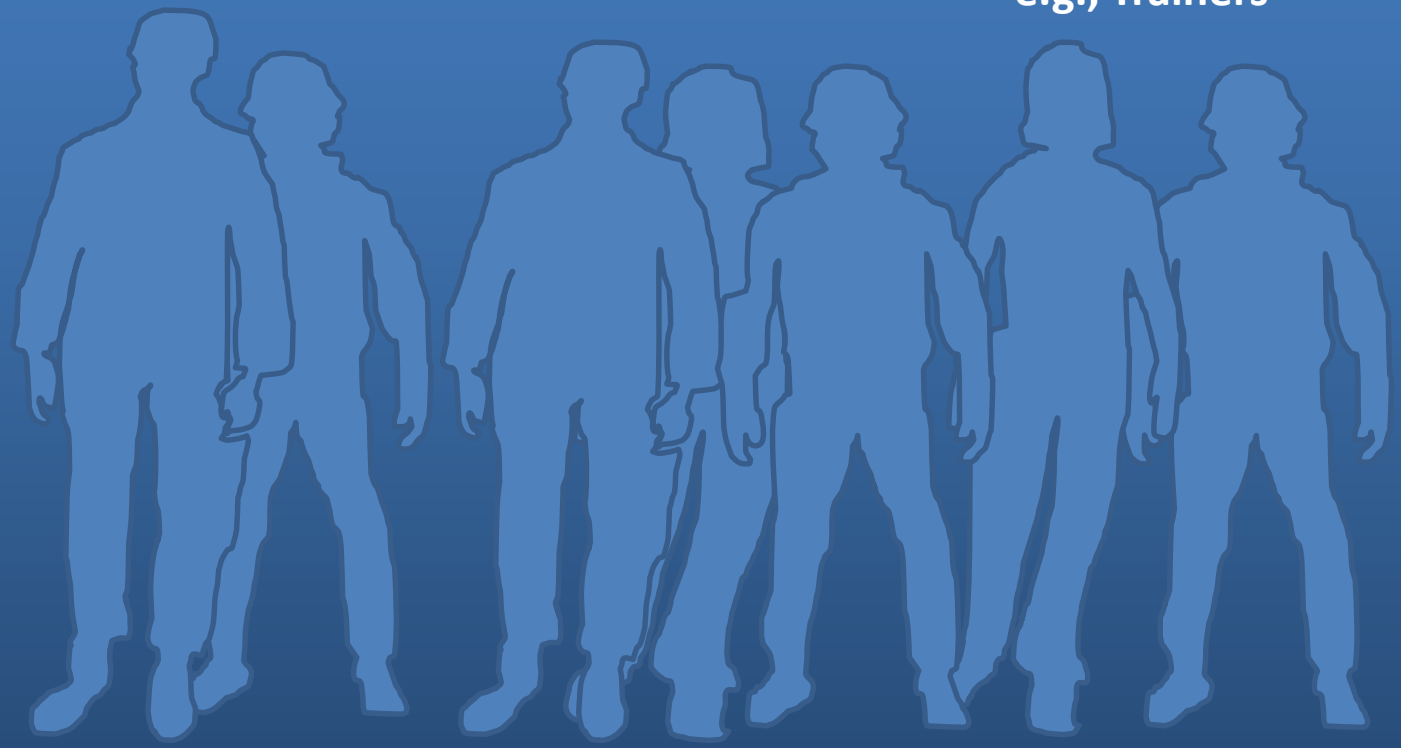
Methodology

Target Audience Description

Operators

Maintainers

Support Team
e.g., Trainers



Other

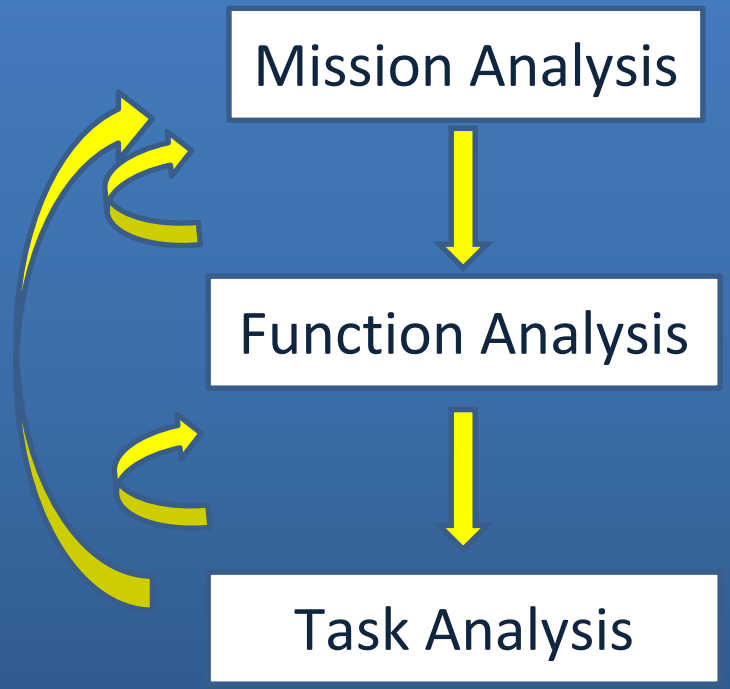
?

e.g., Passengers, Other FoS Users, Bystanders

Mission Task Analysis

Part of the overall systems engineering process – a team effort

Decompose mission capabilities into functions and tasks



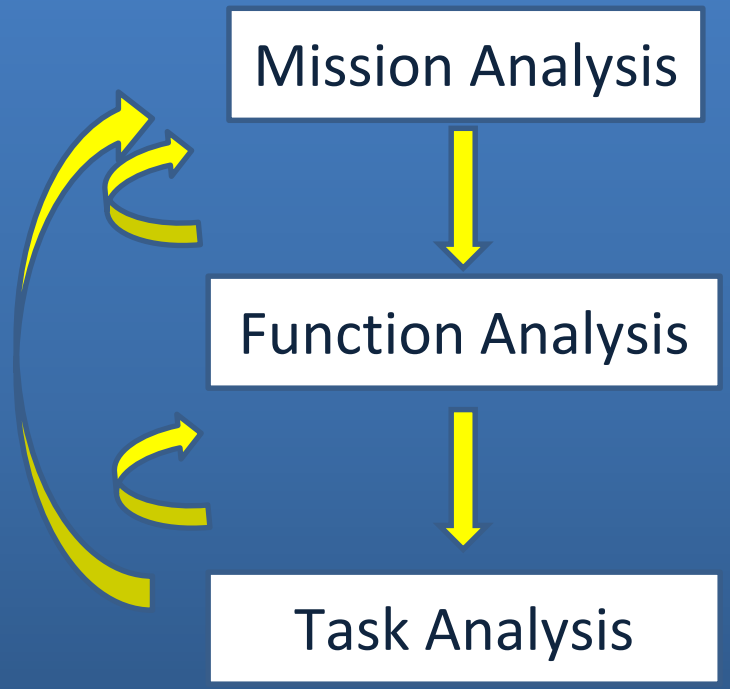
Consider the human as part of the overall system

Human capabilities and limitations factored into the design EARLY

MIL-STD-46855A

Mission Task Analysis

Commercial off the shelf or transitioning technologies



Allocate functions to hardware, software, and/or human

Factors into Systems Engineering top down requirements decomposition process

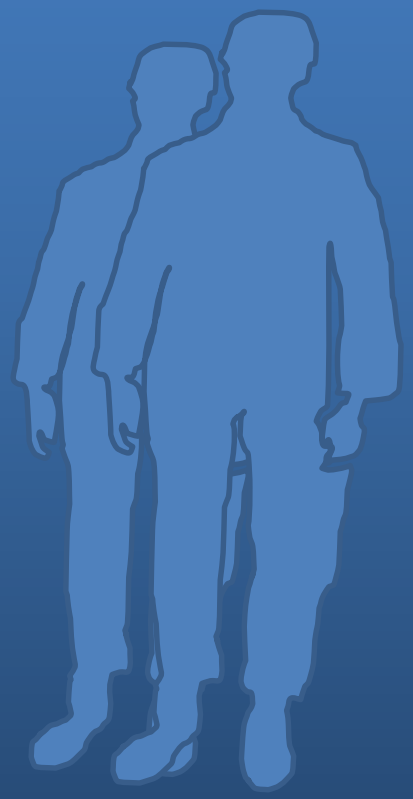
Empowering the human to excel in tasks that they do better than machines

Designing hardware and software to assist humans when machines can do tasks better

Example

Notional example:

Security Forces need assistance patrolling military bases and apprehending threats.



The following capabilities will be acquired to augment the existing forces:

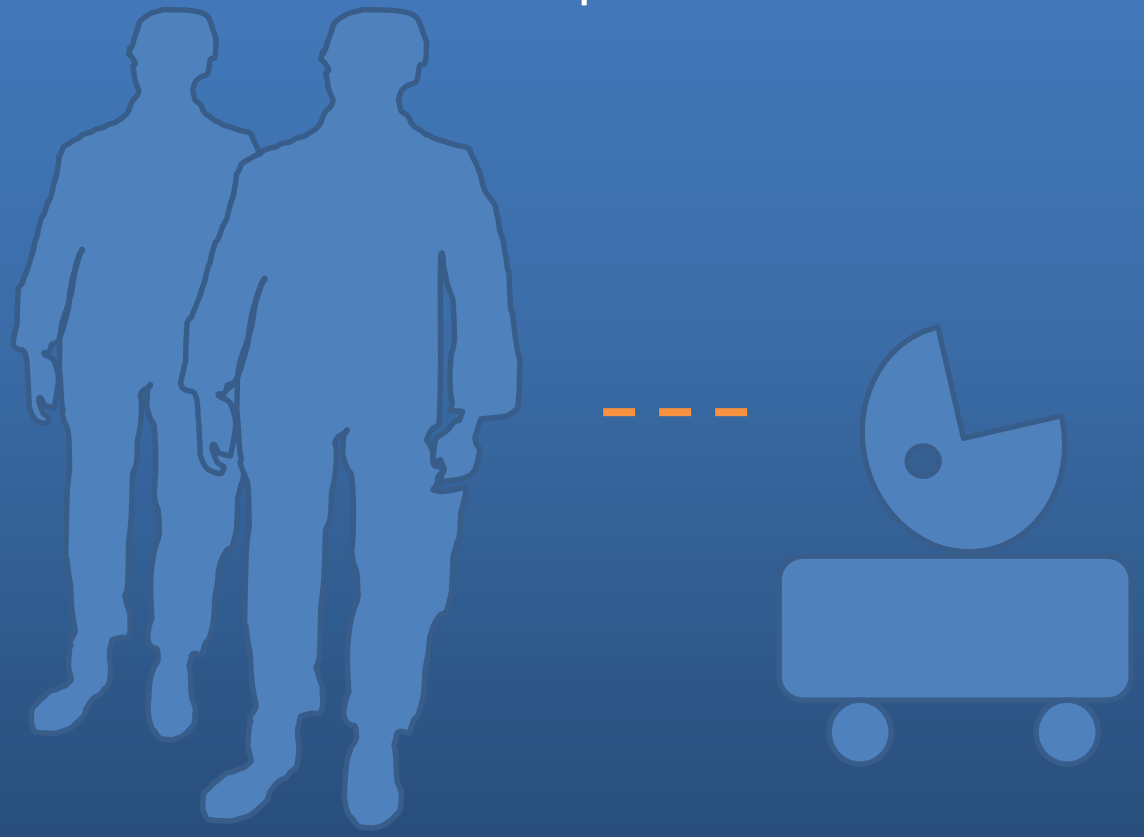
‘Security Forces Bot (SFB)’

- Autonomous, mobile patrolling of perimeters of military bases
- Sense and detain airborne intruders (UAVs)
- Sense and detain intruders on foot
- Work as a team with other SFBs and also with [human] security forces

Example

Total system performance

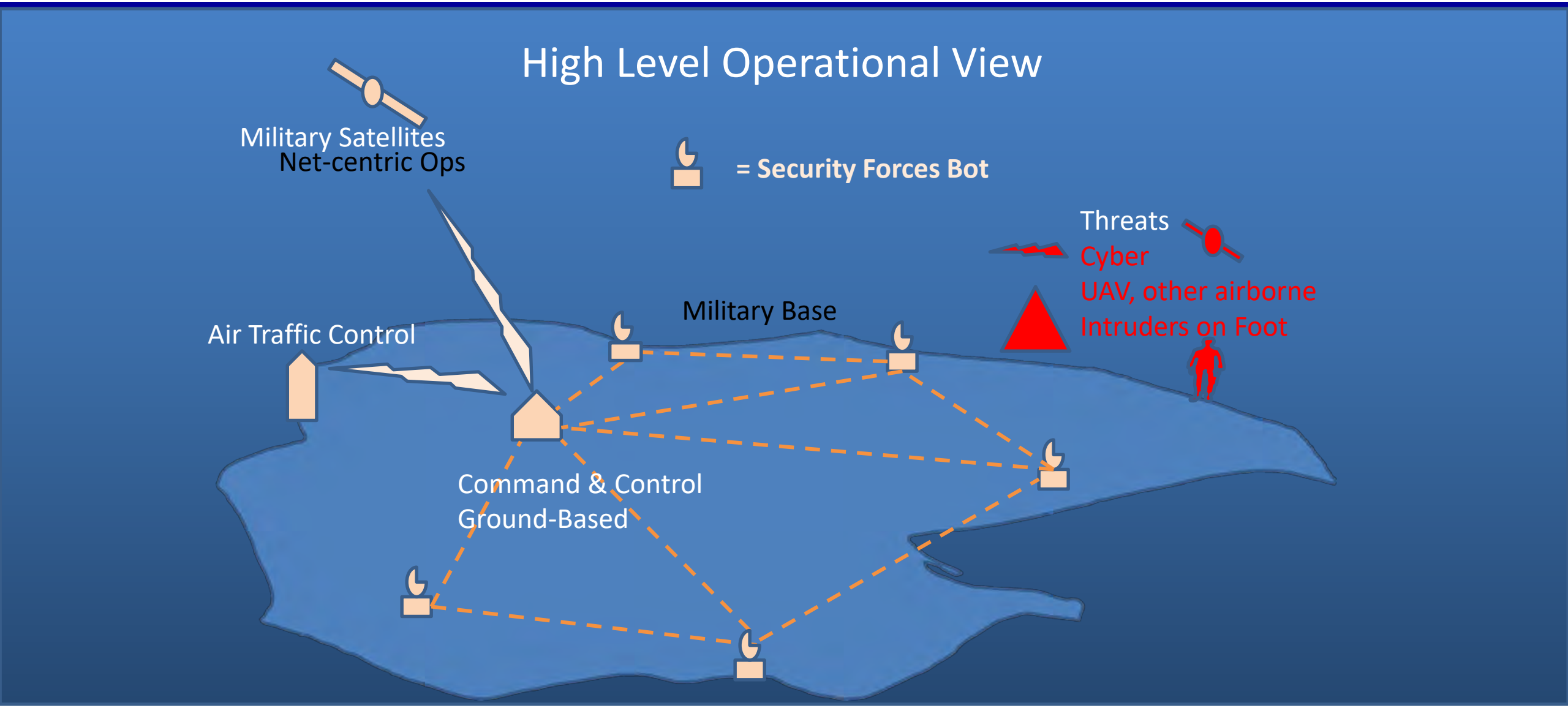
…the relative and combined performance of humans and systems



Empowering the human to excel in tasks that they do better than machines

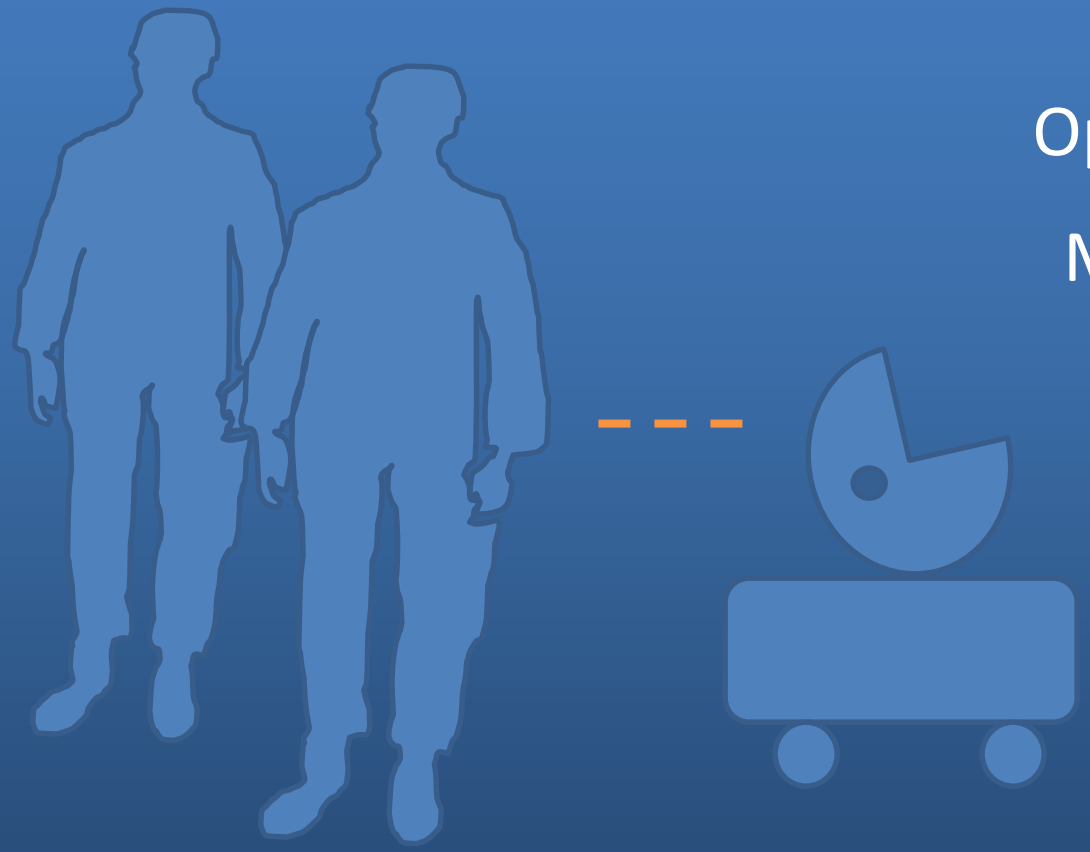
Designing hardware and software to assist humans when machines can do tasks better

Example



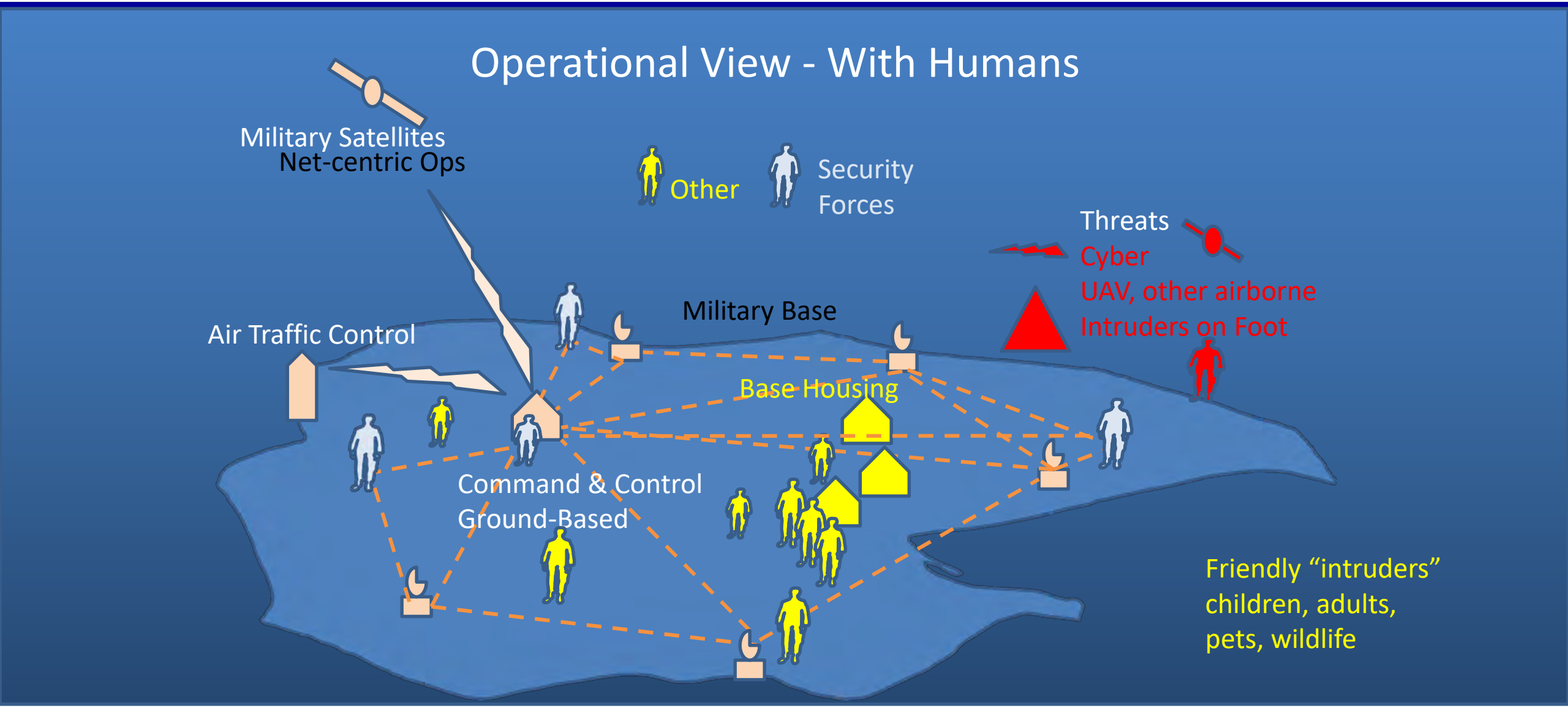
Example

Methodology: Begin with the Target Audience Description



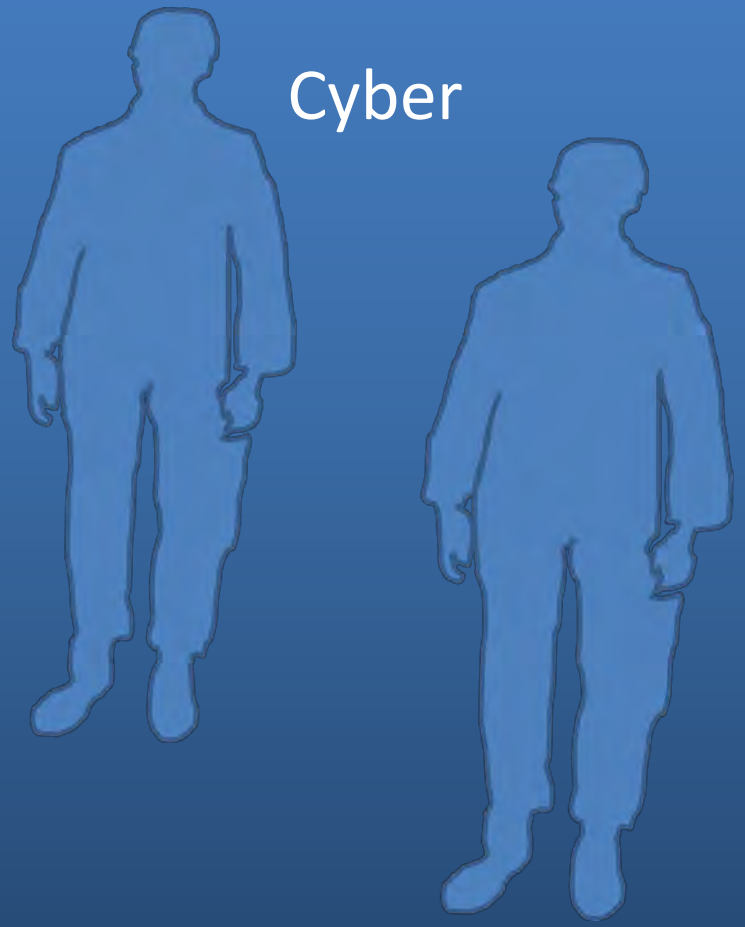
- Operators
- Maintainers
- Support Personnel
- Other

Example



Example

Consider the following areas of focus:



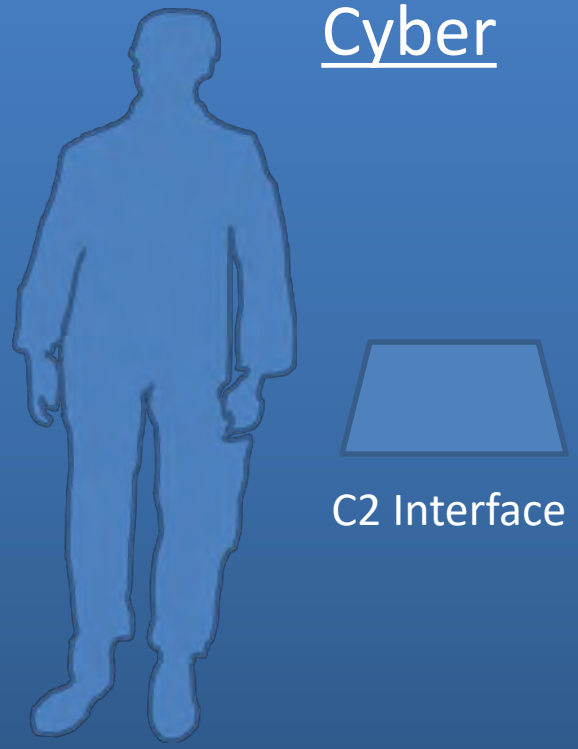
Cyber

Augmentation

Autonomy

Example

Cyber



C2 Interface

Command and Control (C2) Operator

Human- System requirements might address:

- Alerting/notification of cyber threats
  - Software-related
  - Hardware-related
  - Overall system
  - Individual SFB cyber issues
- Decision-aiding
  - Responding to cyber threats
  - Understanding the impact/scope of cyber threats
- Ability to easily update system to respond to new emerging threats

Example

C2 Interface

Cyber

Human- System requirements might address:

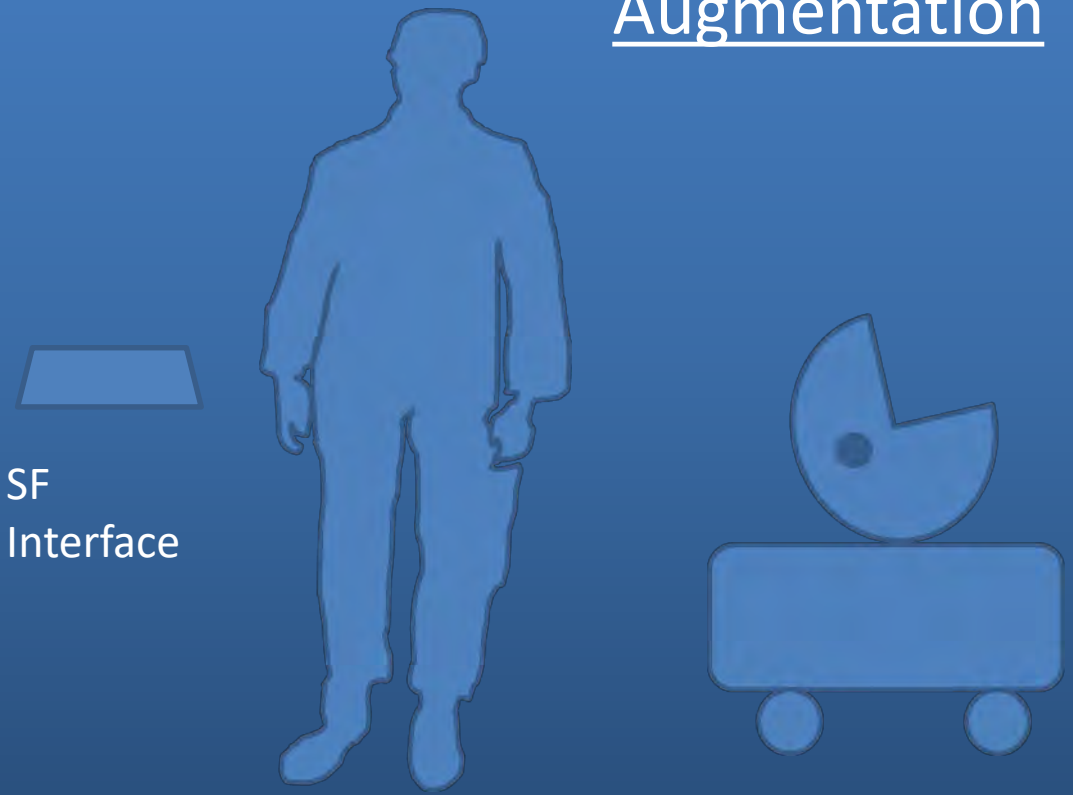
- Alerting/notification of cyber threats
  - Software-related
  - Hardware-related
  - Overall system
  - Individual SFB cyber issues
- Decision-aiding
  - Responding to cyber threats
  - Understanding the impact/scope

The C2 Interface shall provide recommended courses of action to avert <type A> threat to the C2 Operator within <D> seconds of detection. Verify by demonstration.

respond to new emerging threats

Example

Augmentation

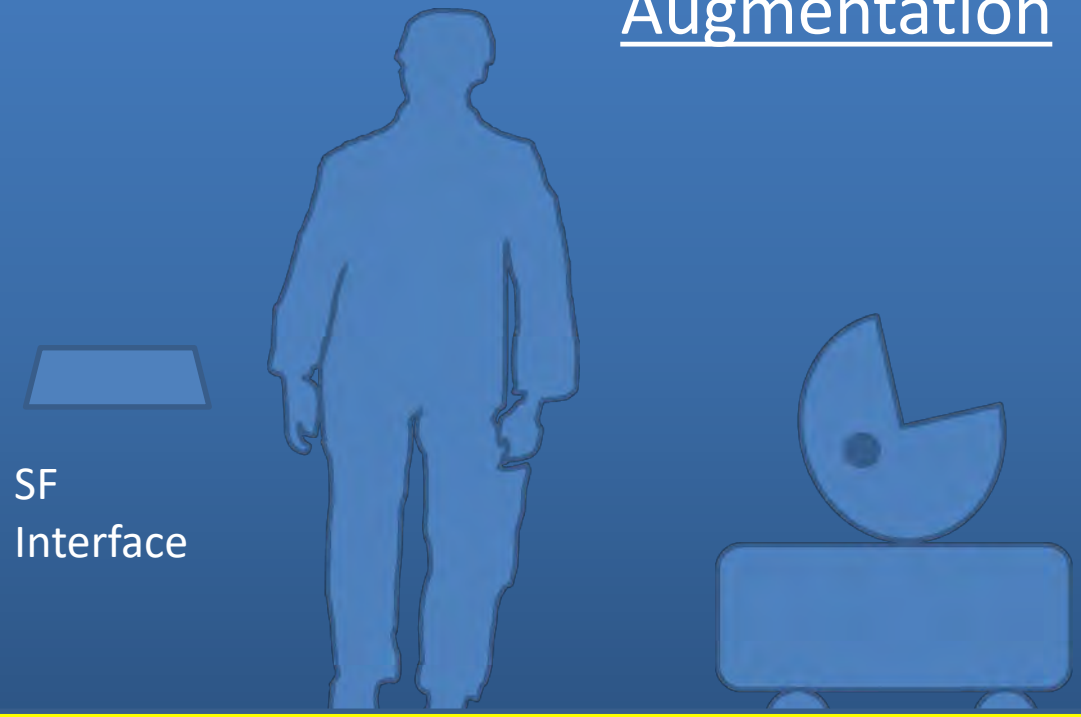


Human- System requirements might address:

- Teaming
- Communication
- Decision-aiding
- Override of automation
- Training
- Socialization/trust
- Safety
- Survivability
- Maintainability

Example

Augmentation



Human- System requirements might address:

- Teaming
- Communication
- Decision-aiding
- Override of automation
- Training
- Socialization/trust
- Safety

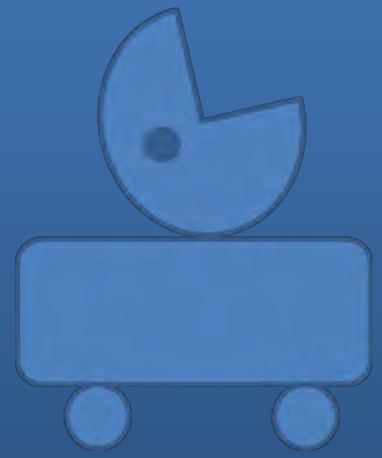
The SF Interface shall allow the trained SF Operator to override autonomous operation of a single SFB to manual control within <C> seconds. Verify by demonstration.

Example

Human-Systems requirements might address:

- System protected from unauthorized users
- Easy changes to software modules (by authorized users) – command, control, and teaming “rules”
- Communication
- Decision-aiding
- Safety
- IFF/Survivability – Friendly “intruders”
  children, adults, pets, wildlife
- Maintainability- diagnostics
- Sustainment- # of people required to support and sustain over the lifetime of the system
- Training- understanding evolution of changes to SFB

Autonomy



Example

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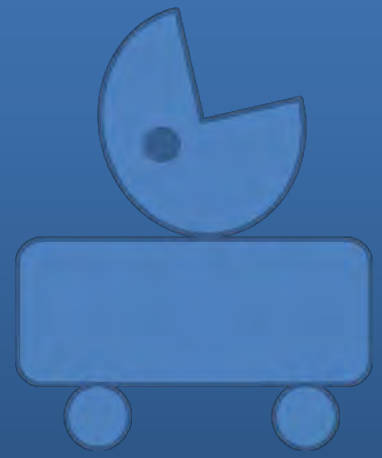
Autonomy



The SFB software shall be capable of field updates for <teaming rules> performed by trained SF Maintainers within <D> minutes. Verify by demonstration.

Postured to Optimize Warfighter Capability

711 HPW/HP - AF HSI Analysts

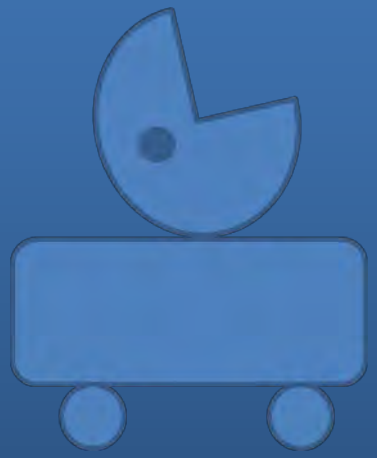
- Postured to optimize warfighter capability within current and emerging technologies

HSI Lab

- Anthropometrics
- Task Analysis
- Usability
- Exoskeleton augmentation

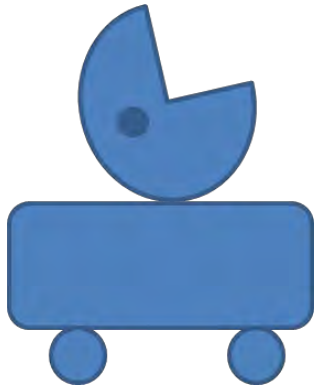
Expanding talented HSI analyst workforce

- Cyber SMEs
- Engineers
- Acquisition professionals
- Doctors
- Physiologists



Contact Information

HP workflow:
711HPW.HPWorkflow@us.af.mil



TM 9-XXX-XXX-10

OPERATOR'S MANUAL
BASELINE AND PMCS

HUMAN, COMBAT, MULTI-DOMAIN

HEADQUARTERS, DEPARTMENT OF THE ARMY
DATE

Human – 10 PMCS
Baseline – Preventive Maintence Checks and Services

Physical – Cognitive - Belief

1. What Should We Measure?
2. What Can We Measure?
3. How Do We Measure? (Tools)
4. How Well Does the Tools Measure?
5. What Tools Do We Need to Measure Better?

Always a Step Ahead
ARDEC
ARMAMENTS

Optimizing Future Soldier Systems through the Incorporation of Human Aspects into the Soldier as a System Domain using the Systems Modeling Language

Sean F. Pham
Shauna M. Dorsey, Ph.D.

NDIA Human Systems Conference, 13 March 2018

UNPARALLELED
COMMITMENT
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SOLDIER AS A SYSTEM

Problem: The U.S. Army has historically focused on the development and optimization of Soldier **equipment**, leading to integration challenges between Soldiers and their equipment.

Best:
- Unmanned aerial vehicles
- Operational rations
- Organization/leadership
- Quality of life standards, etc.

It's not just about Soldier equipment. We must also understand and predict the performance of the ***full system***, inclusive of the Soldier, his/her equipment, and the tasks he/she must perform.

SOLDIER SYSTEM ENGINEERING ARCHITECTURE

Objectives: Create a principle-based Soldier architecture and framework to enable a **system level tradeoff analysis** of the Soldier as a System (SaaS) domain.

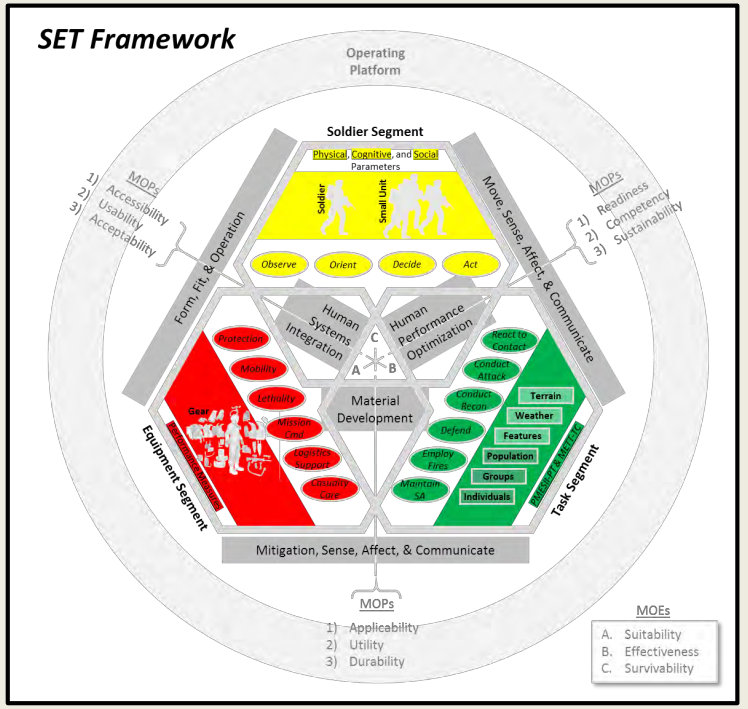
- Create the **foundation for design parameters** for the next generation of Soldier systems and subsystems, which considers the complete **Soldier as a System** with the full complement of equipment, the human performance capabilities, and the mission tasks.

Anticipated Outcomes:

- Increased efficiencies and optimized performance of the Soldier as a System.
- Enterprise approach across Soldier-Small Unit Science and Technology (S&T) efforts, combat developers, and acquisition communities.

SOLDIER SYSTEM ENGINEERING ARCHITECTURE

Purpose: Utilize Systems Engineering tools and processes to allow stakeholders across the Soldier Enterprise to manage the overwhelming complexity of the Soldier as a System domain.



Soldier System Engineering Architecture (SSEA) is integrating these tools and processes for the Soldier Enterprise.

Soldier as a System (SaaS) Reference Model:

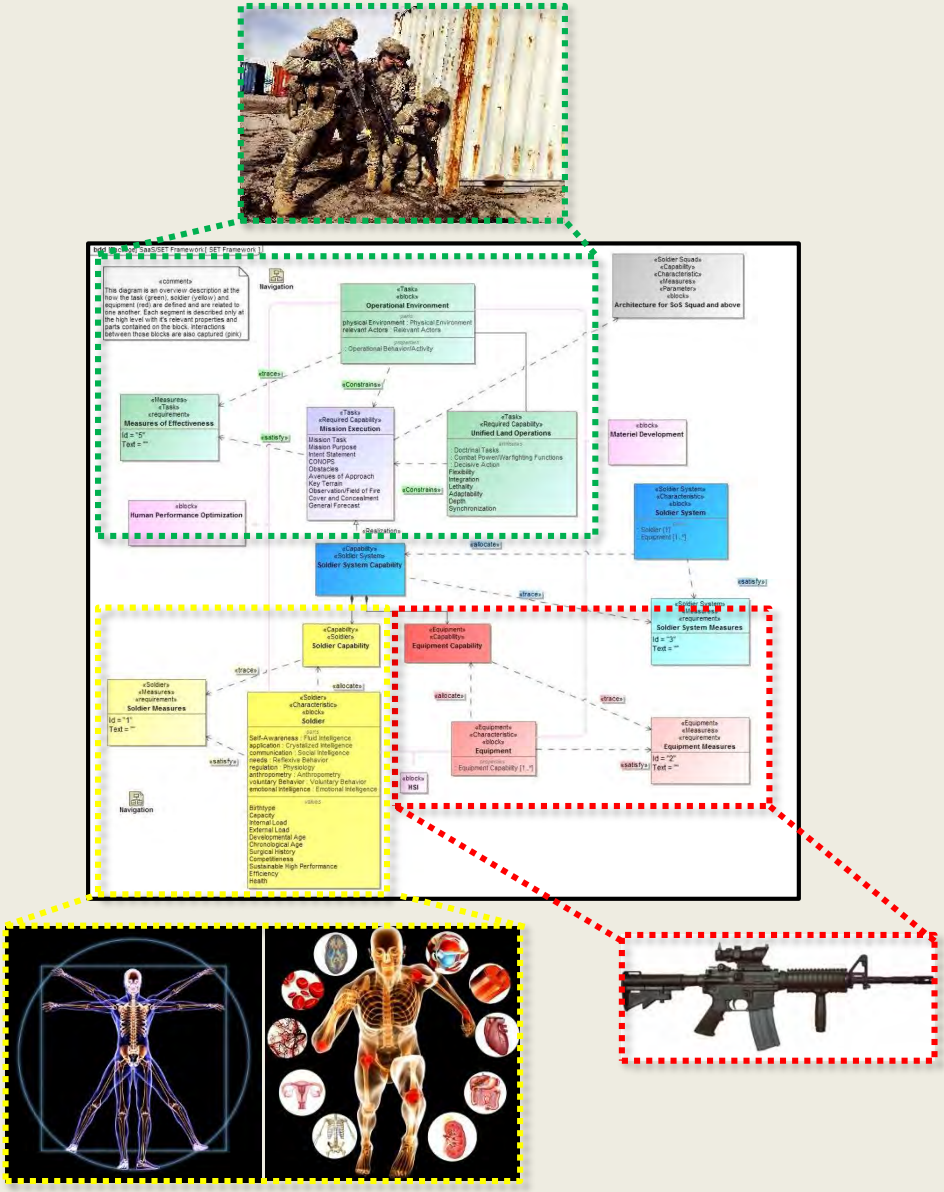
- **Characterizes** the Soldier as a System **domain** in terms of the human dimension, the materiel solutions, and the operational environment (i.e., the Soldier, Equipment, Task [SET] framework).
- Formalizes the **definition** of the **SaaS** domain.

  → Elements of the Soldier, Equipment, and Task, along with their interactions and interrelationships.

System Modeling Language (SysML):

- **Captures the system model** and **defines the boundaries** of the system space.

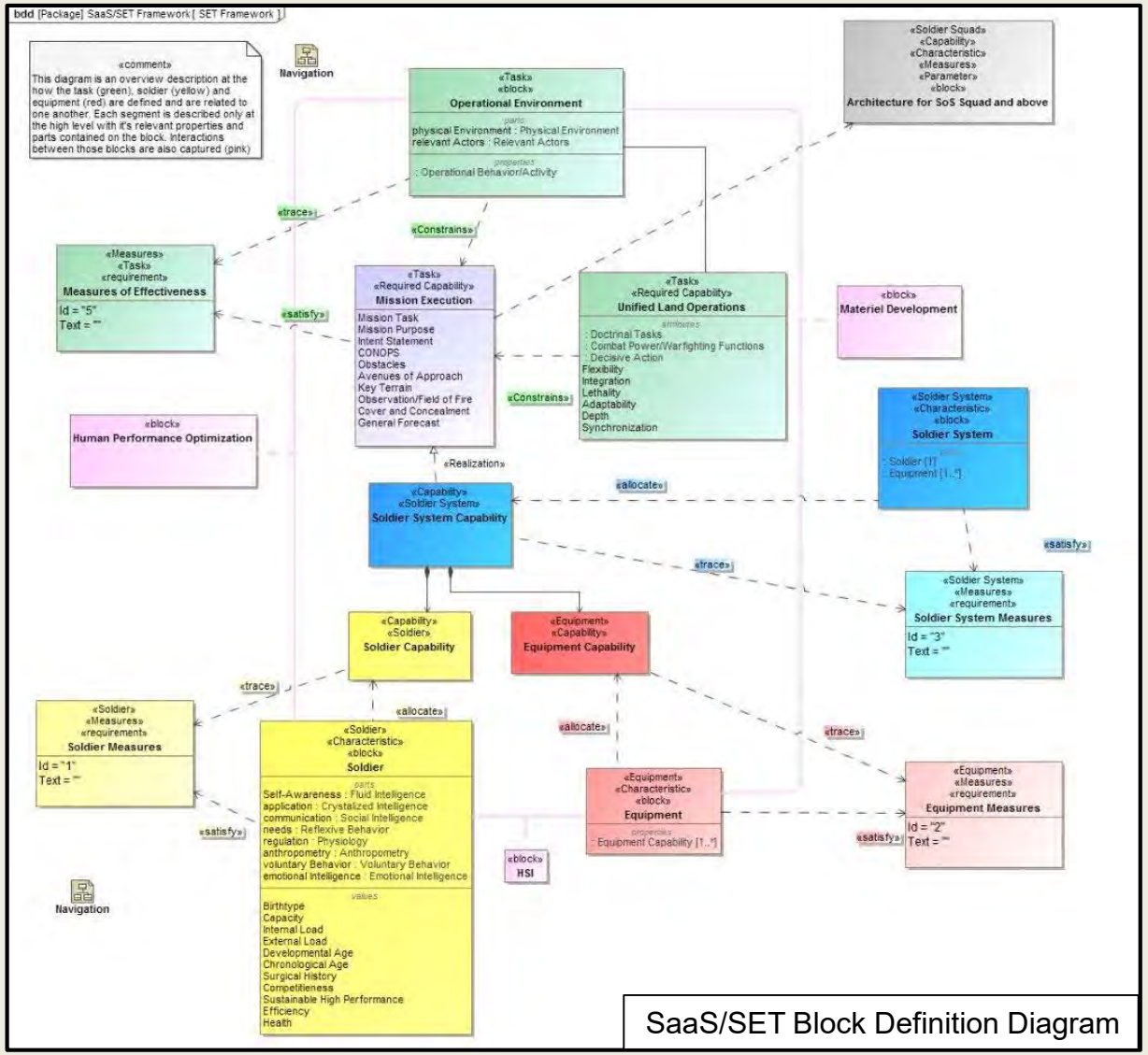
  → Enables decomposition of the SaaS domain and establishes a common vocabulary.
- Provides a **common underpinning for SSEA**, allowing **stakeholders** to further **understand** their piece of the SaaS domain and its impact points over the full system space.



SaaS Model Structure

Purpose of the Model Structure:

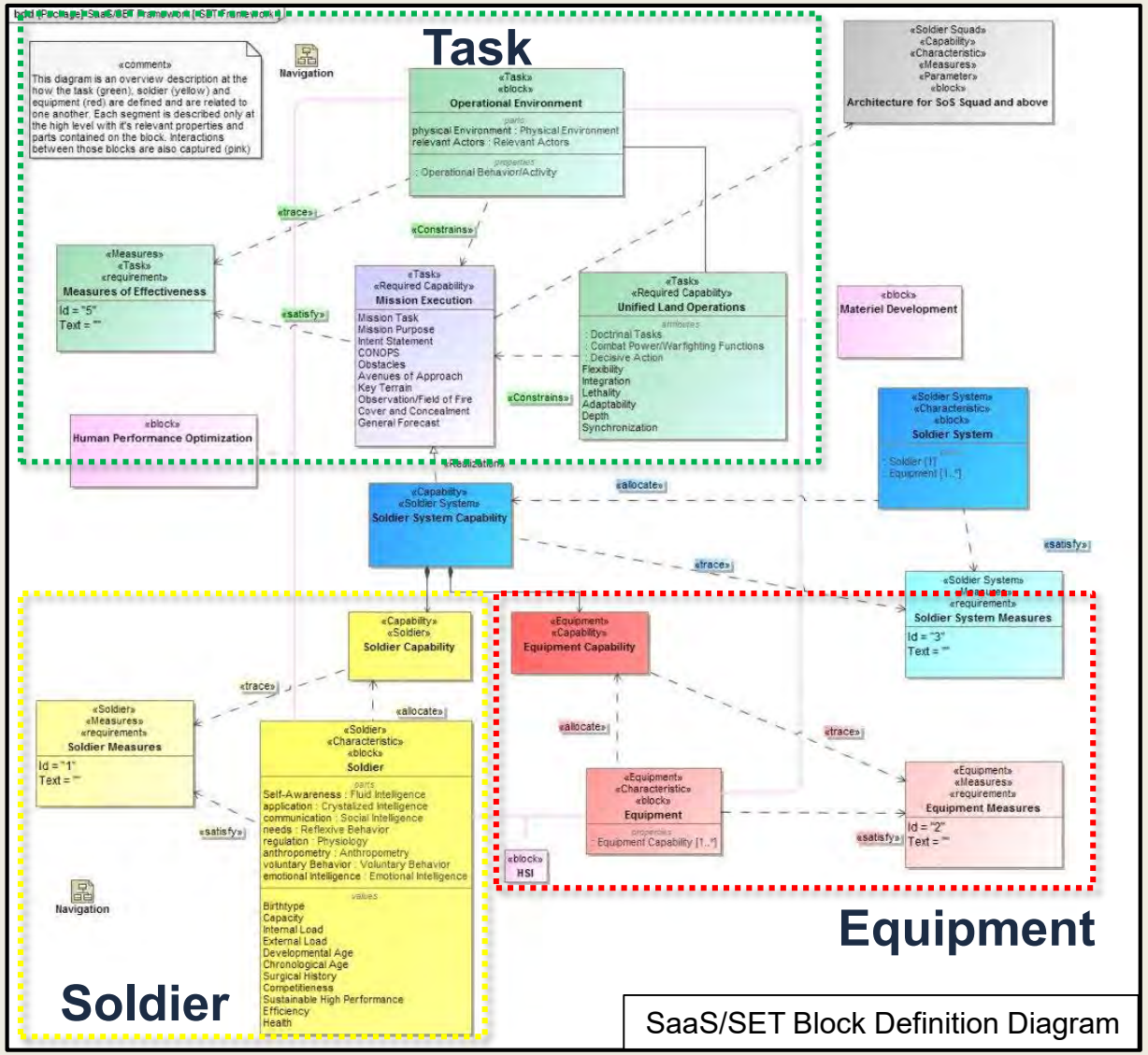
- Define the domain/system space (SaaS) and boundaries.
- Serve as a central hub for the defined SaaS components and relationships.
  - Comprised of the Soldier system within an operational context.
  - Displays any interrelationships between the primary model components.



SaaS/SET Block Definition Diagram

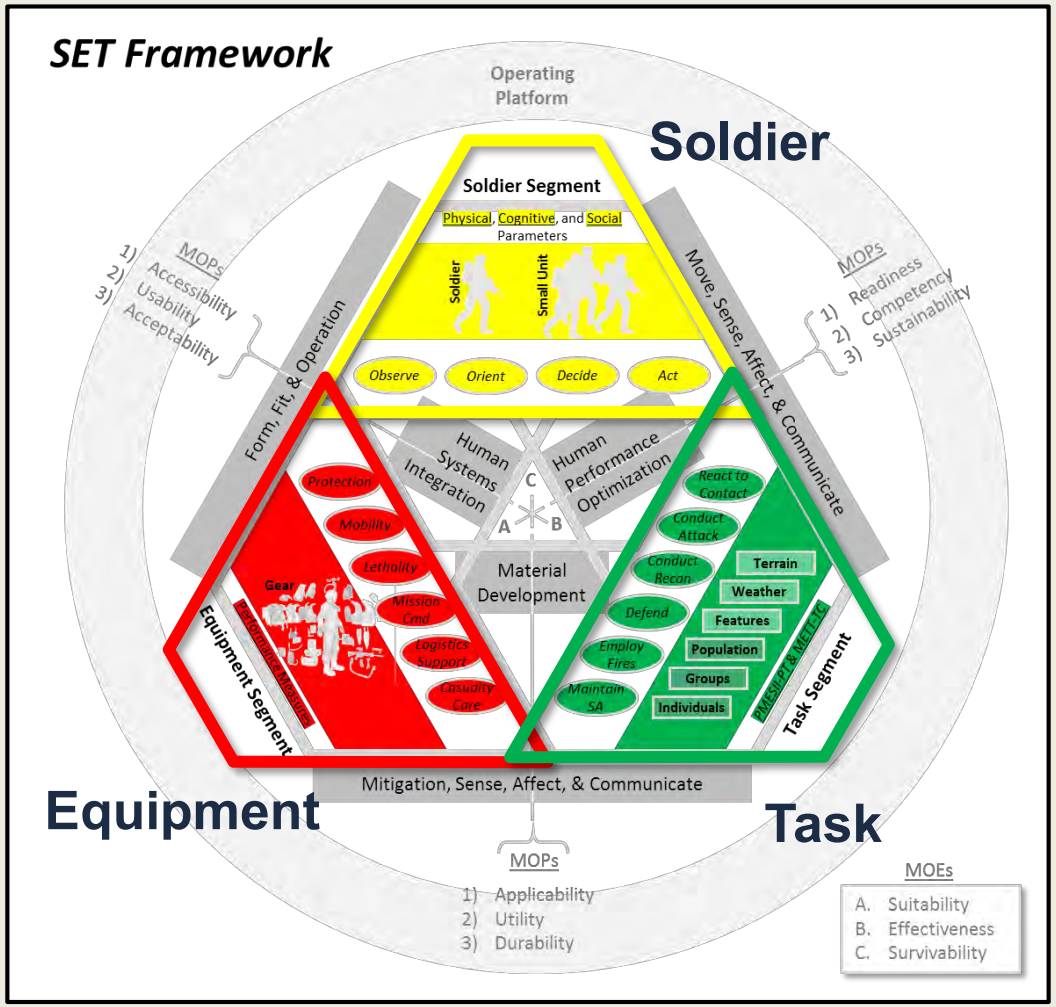
SaaS Model Structure

Scenario: Soldier engaging an enemy target.



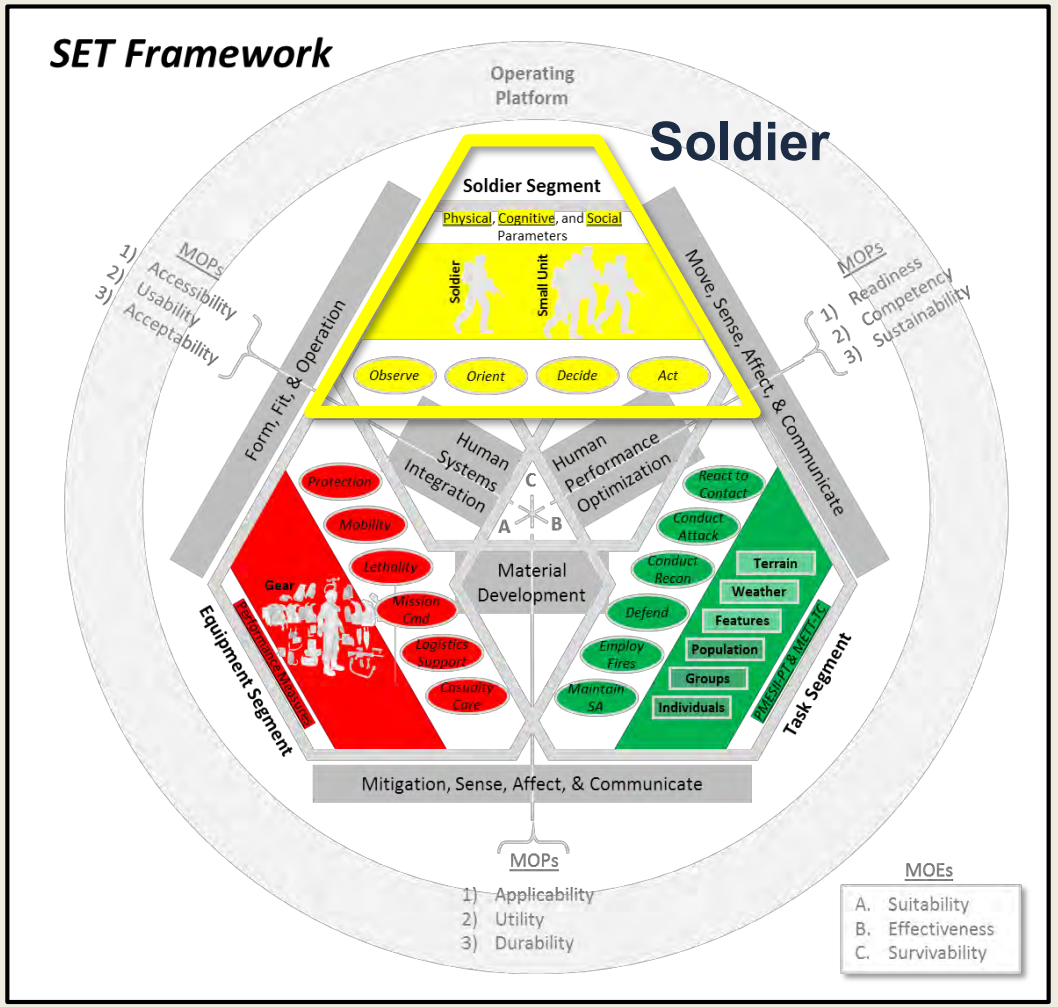
SOLDIER, EQUIPMENT, AND TASK SEGMENTS

Purpose: Define the elements and relationships contained within Soldier, Equipment, and Task (SET) segments of the Soldier as a System (SaaS) model.

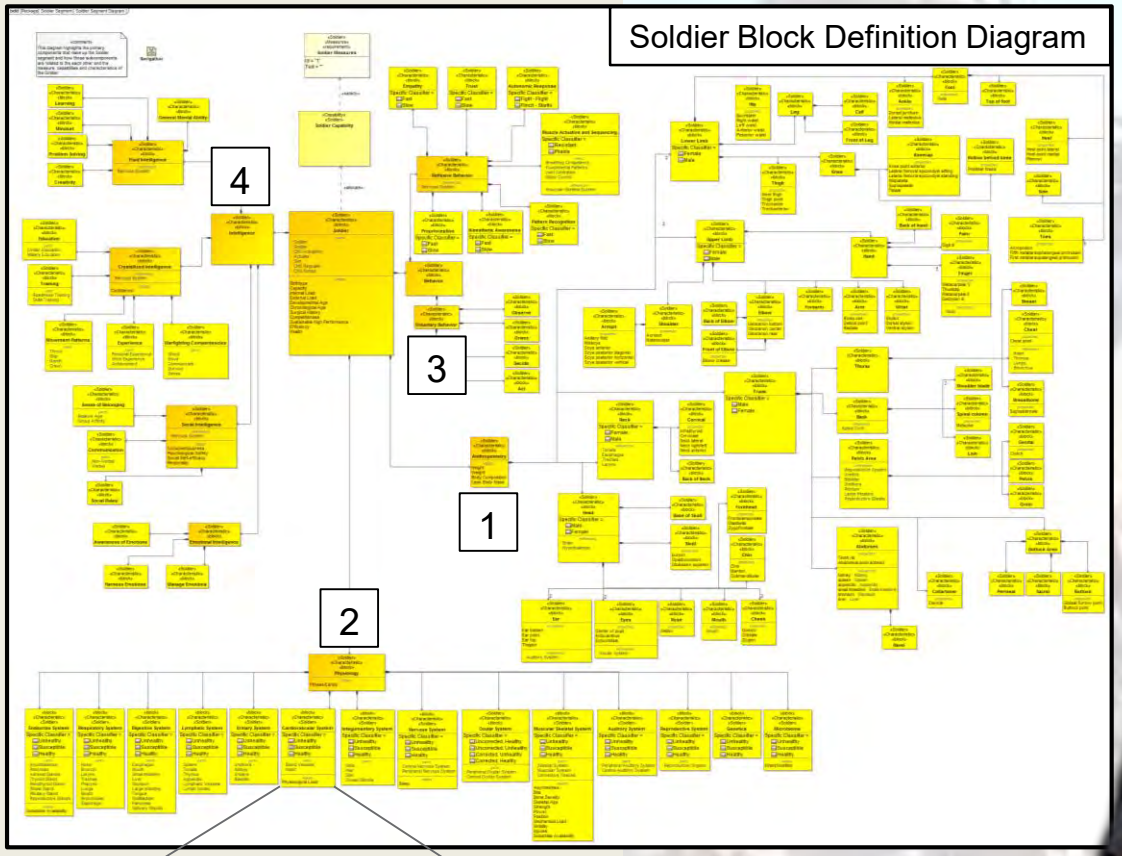


SOLDIER SEGMENT OF THE MODEL

Purpose: Define the elements and relationships within the human dimension, which includes cognitive, physical, social, and emotional parameters to further characterize the Soldier.



SOLDIER AS A SYSTEM: SOLDIER SEGMENT OF THE MODEL



Four Main Components:

1. *Anthropometry – Physical structures of the human*
2. *Physiology – Internal regulatory systems of the human*
3. *Behavior – Voluntary (i.e., cognitively founded) and reflexive (i.e., "hard-wired") behaviors*
4. *Intelligence – Fluid (i.e., creativity and learning), crystalized (i.e., prior skills and knowledge), social, and emotional intelligence*

Component Classifiers:

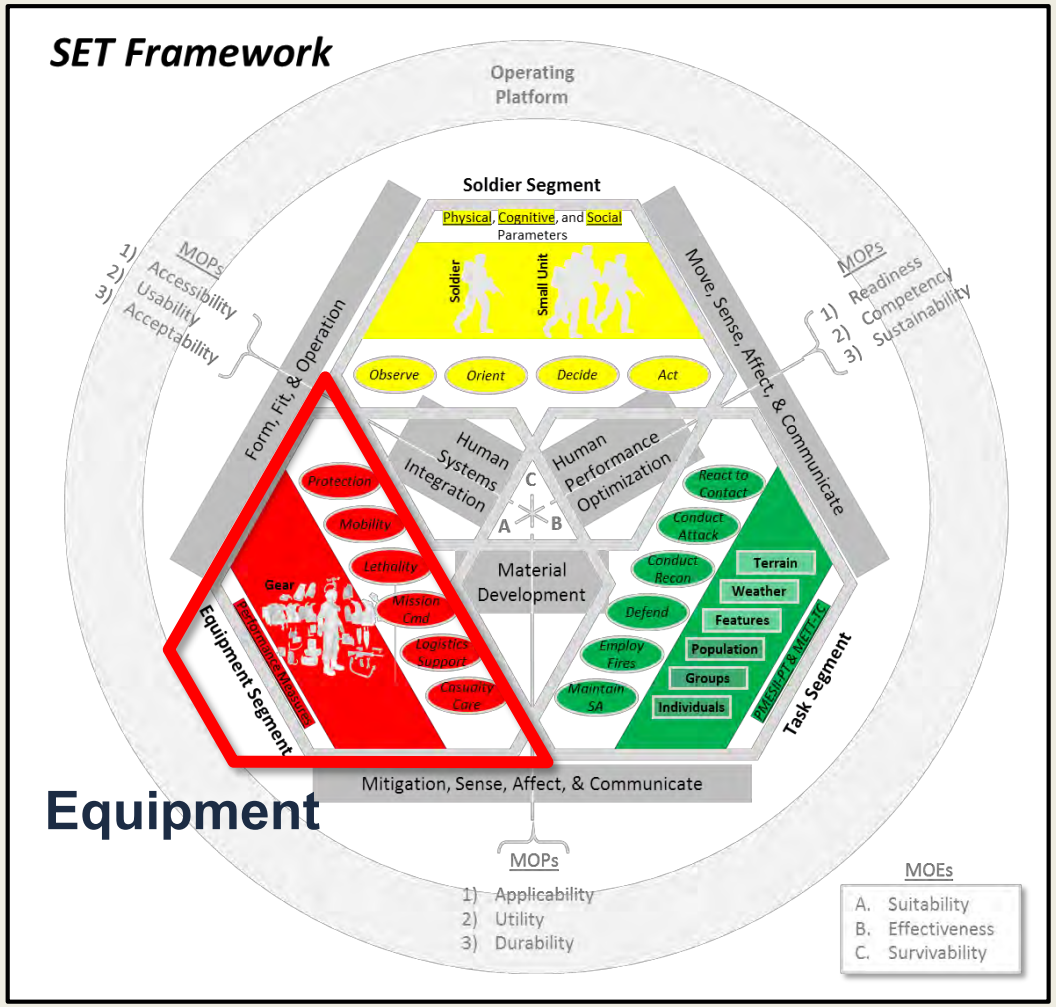
- *Size and shape*
- *Health state*
- *Response*
- *Creativity and learning*
- *Education and experiences*
- *Communication style*
- *Emotions*

Ports / Interactions (examples):

- *Shoulder / Support, Stabilize*
- *Hand / Support, Secure*
- *Finger / Control Magnitude, Actuate*
- *Eye / Signal Sense*
- *Body / Support, Secure, Attach*

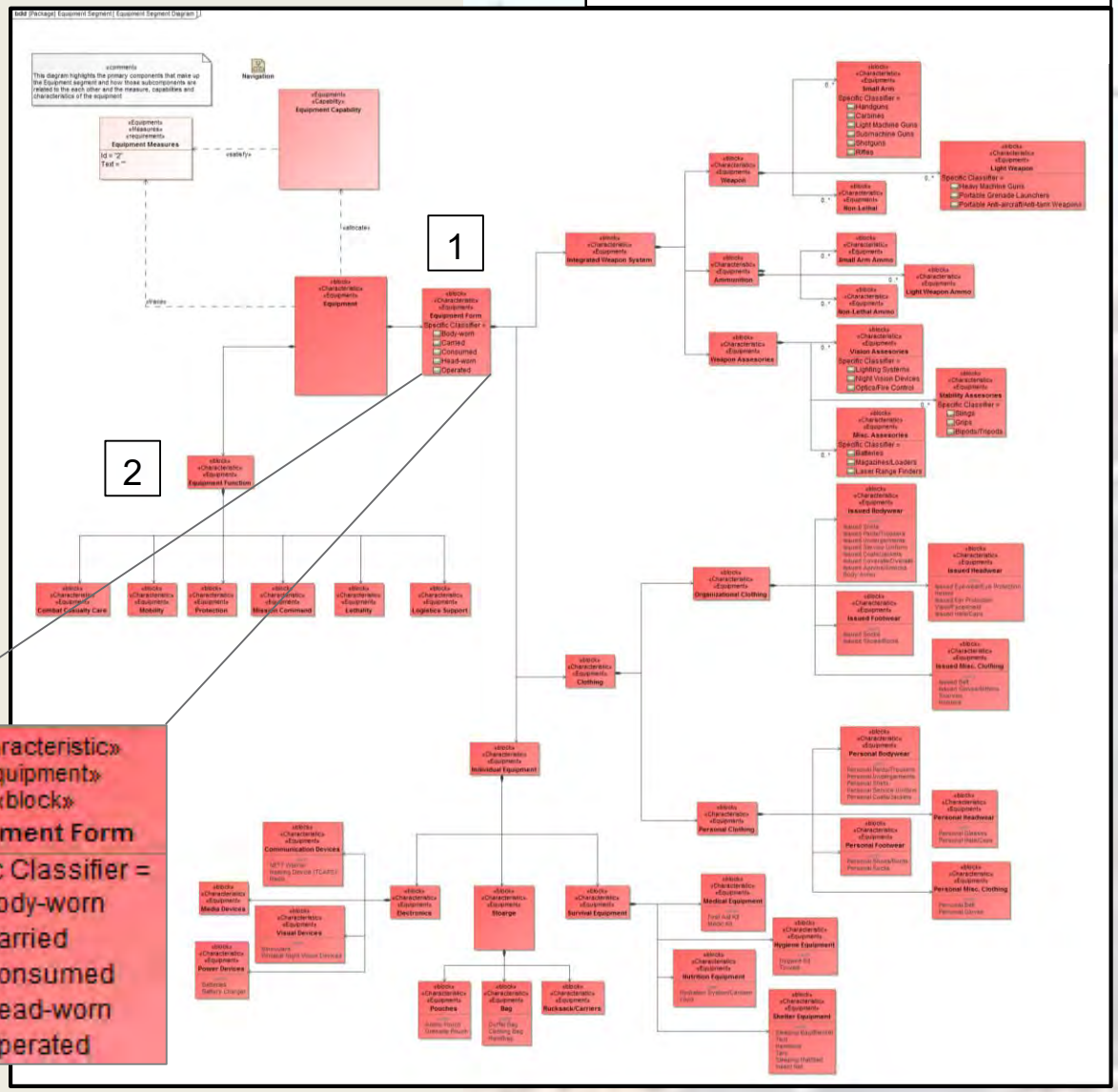
EQUIPMENT SEGMENT OF THE MODEL

Purpose: Define the elements and relationships within the material development dimension, including the type, form, and function of the equipment and how it relates back to its requirements.



SOLDIER AS A SYSTEM: EQUIPMENT SEGMENT OF THE MODEL

Equipment Block Definition Diagram



Two Components:

- *Equipment Form – Integrated weapon system, clothing, and individual equipment*
- *Equipment Function – Combat casualty care, mobility, protection, mission command, lethality, logistics support*

Component Classifiers:

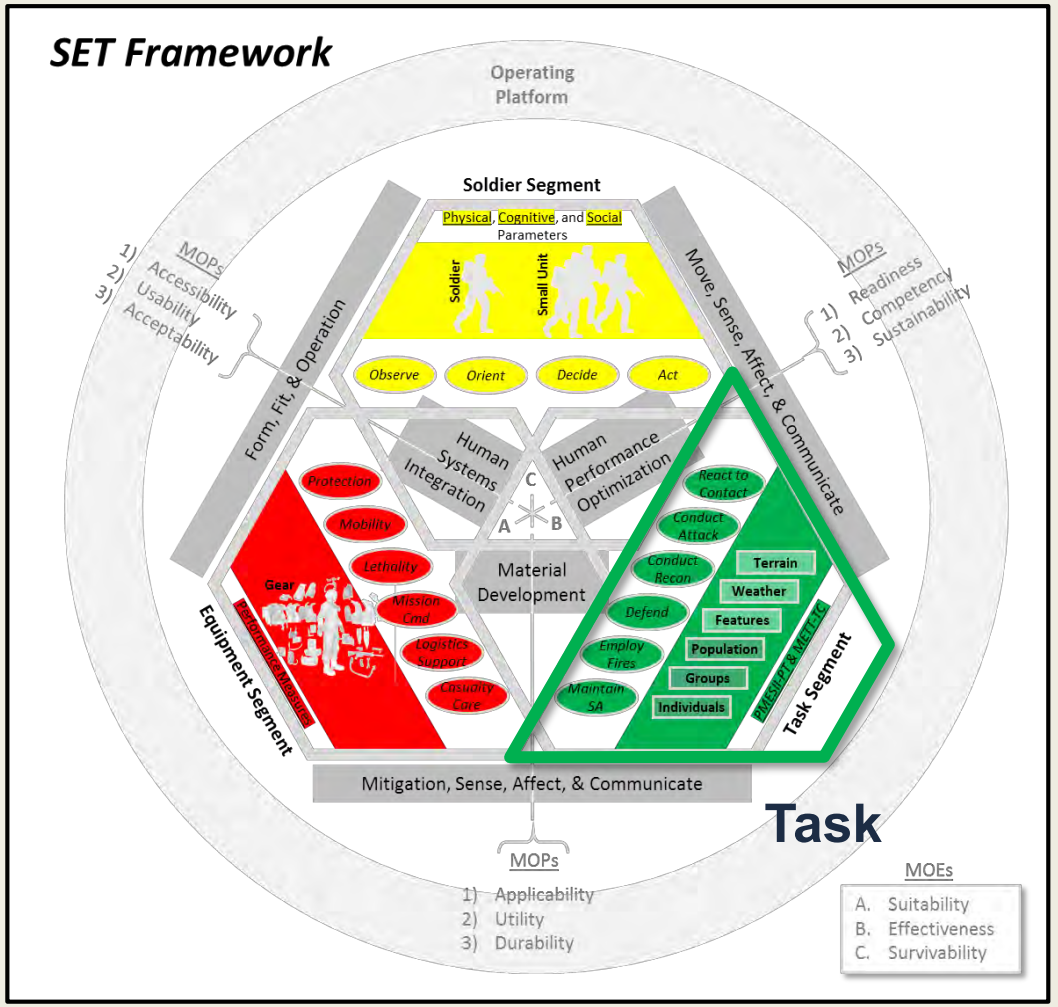
- *Forms of Equipment*
  - *Body-worn*
  - *Carried*
  - *Consumed*
  - *Head-worn*
  - *Operated*

Ports / Interactions (examples):

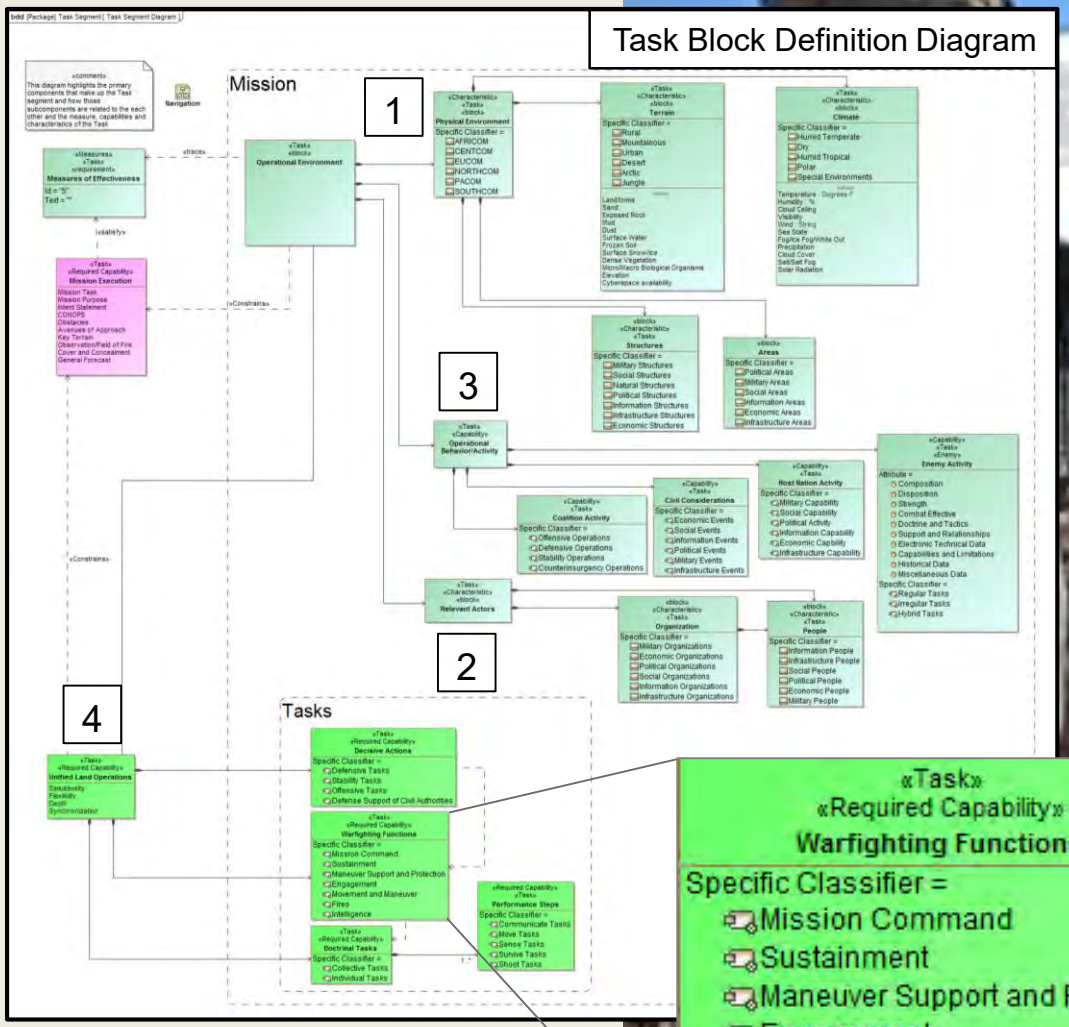
- *Buttstock / Support, Secure*
- *Improved Outer Tactical Vest / Support, Stop, Protect*
- *Rucksack / Provision, Store, Hold*
- *Close Combat Optic / Channel, Import, Allow*
- *Eye Protection / Control Magnitude, Regulate*

TASK SEGMENT OF THE MODEL

Purpose: Define the elements and relationships that the Soldier will encounter within a specific operational environment. This focuses primarily on doctrinal mission elements and parameters.



SOLDIER AS A SYSTEM: TASK SEGMENT OF THE MODEL



«Task»
«Required Capability»
Warfighting Functions

Specific Classifier =
- Mission Command
- Sustainment
- Maneuver Support and Protection
- Engagement
- Movement and Maneuver
- Fires
- Intelligence

Four Components:

1. *Physical Environment – Terrain, climate, structures (man-made or natural), and regional areas*
2. *Relevant Actors – Organizations and people*
3. *Operational Behavior and Activity – Coalition, host nation, and enemy activities, along with civil considerations*
4. *Unified Land Operations – Characterizes decisive actions, warfighting functions, and doctrinal tasks*

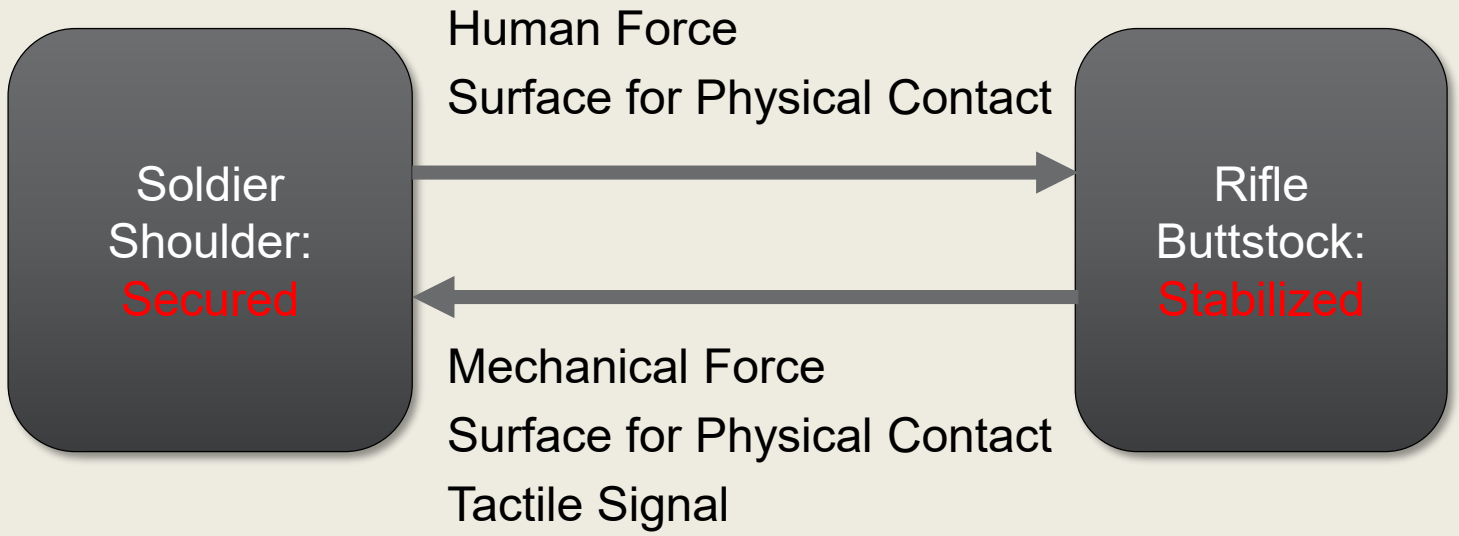
Component Classifiers:

- *Types of:*
  - *Terrain and climate*
  - *Physical structures and areas*
  - *Groups and personnel*
  - *Operational variables (HAMO)*
  - *Operational activities*
  - *Threats and actions*
  - *Tasks and functions*

SOLDIER SYSTEM INTERACTION APPROACH

Purpose: Standardize methods and elements to depict the relationships between the Soldier, Equipment, and Task segments of the SaaS model.

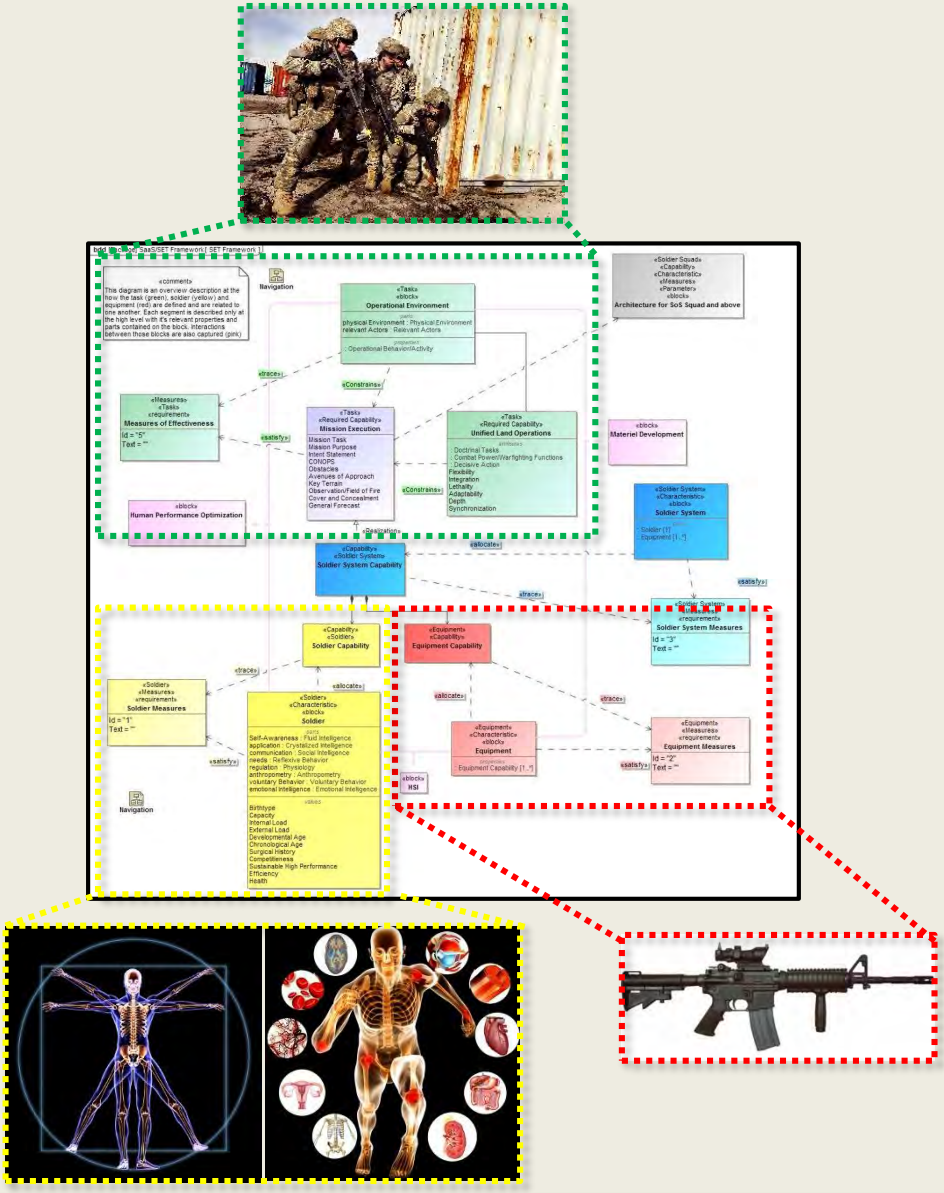
Interaction: Soldier Shoulder to Rifle Buttstock in an active “engagement” position.



Otto K and Wood K. Product Design: Techniques in Reverse Engineering and New Product Development, 1st Ed. 2000.

CONCLUSIONS

- SysML SaaS model captures a system of interest, which include elements related to the Soldier, equipment, and task capabilities.
- Human systems integration aspects are captured to further depict the relationships between the Soldier and their equipment in an operational context.
- SSEA SysML models can be used as a tool to improve decision making through a better understanding of Soldier-equipment interactions, leading to the optimization of future Soldier systems.



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- Joseph Patterson
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- John Turkovich (Draper)
- Jeff Cipolloni (Draper)

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- U.S. Army Aberdeen Test Center (ATC)
- U.S. Army Communications-Electronics Research, Development, and Engineering Center (CERDEC)
- U.S. Army Medical Research and Material Command (MRMC)

THANK YOU

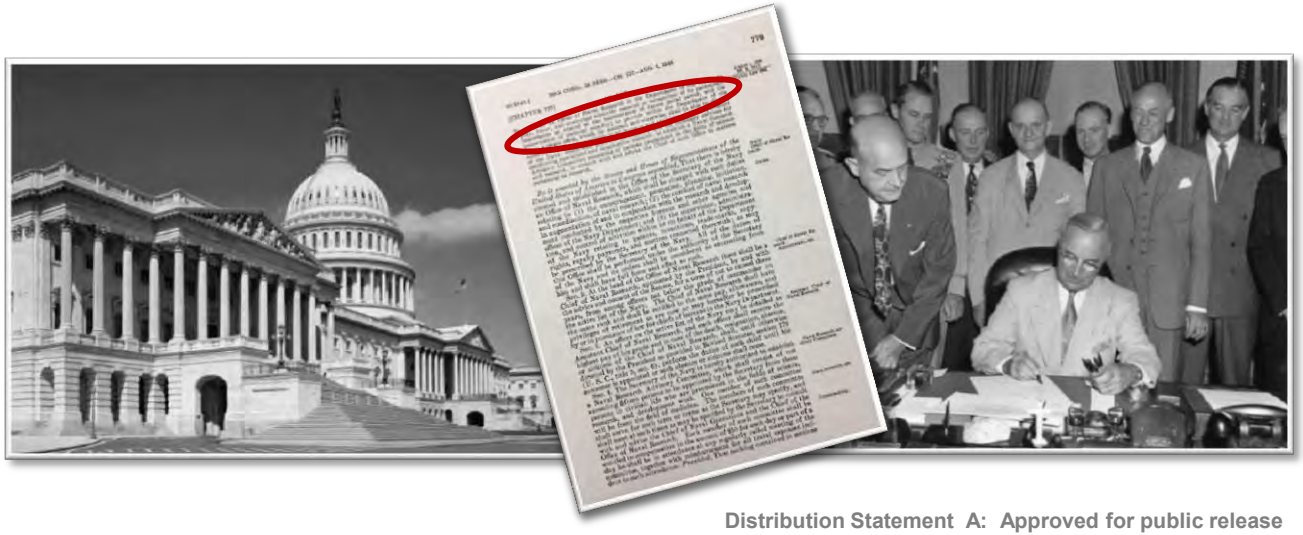
Human Systems in Emerging Domains: *Autonomy, Human Augmentation, and Cyber*

Dr. Paul Zablocky
Chief Scientist (Acting)

March 14, 2018

Lessons from History

"…plan, foster and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power, and the preservation of national security…"

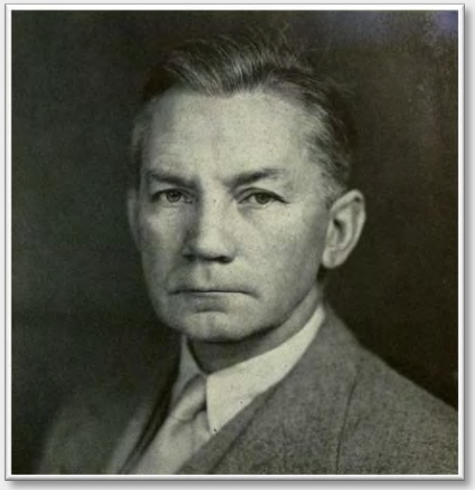


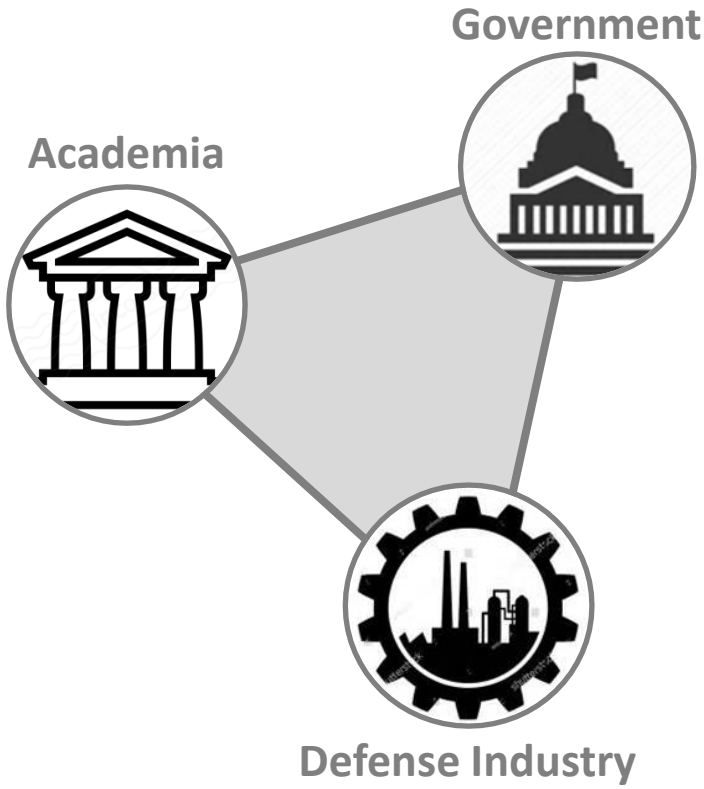
The Naval Research Model c. 1947

U.S. Government Driven

"It is of the utmost importance to our national security that the Navy prosecute a vigorous and well-rounded program of research and development…"

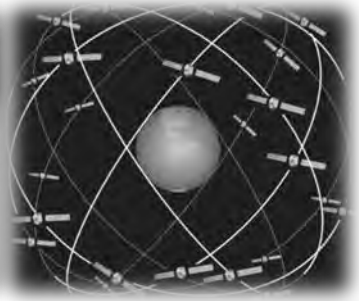
– Secretary of the Navy James V. Forrestal, January 1947



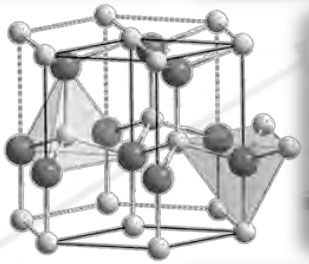


Cold War Success Stories

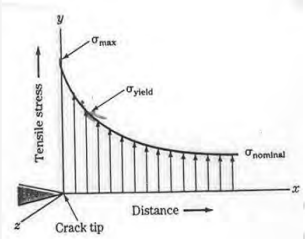
Satellites



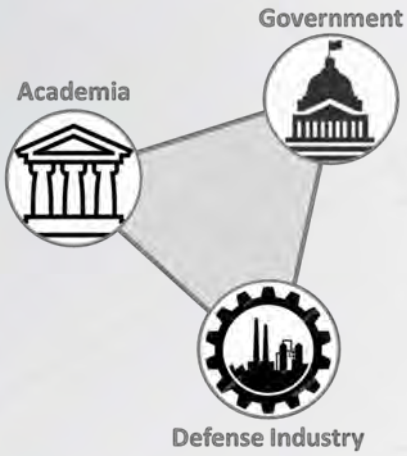
Gallium Nitride



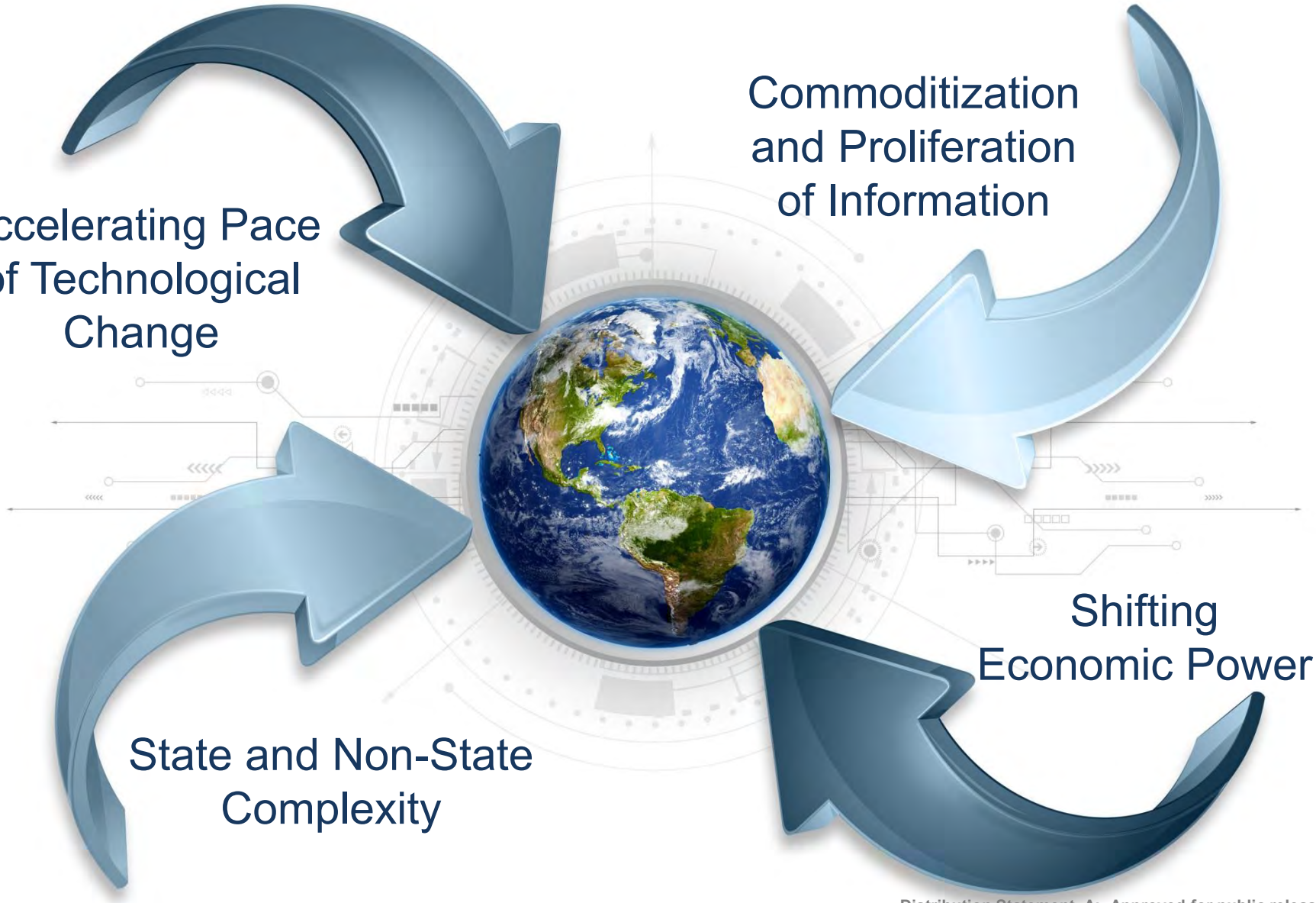
Fracture Mechanics



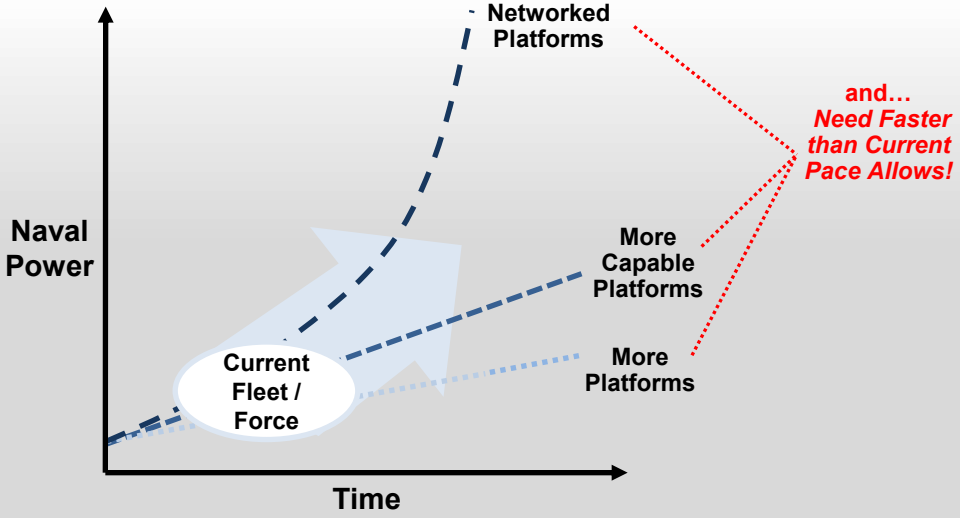
Ballistic Missile Submarine

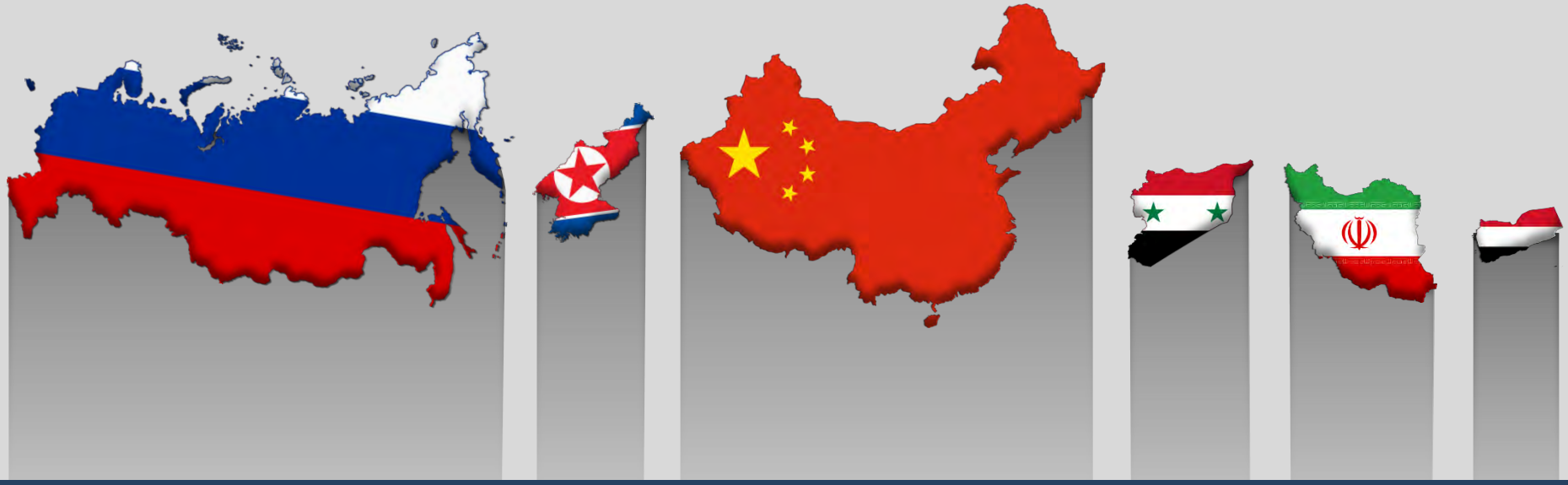


Today's Challenge



U.S. Naval Superiority is NOT Guaranteed





Renewed Urgency in R&D is Needed to Win

The Naval Research Ecosystem c. 2018

Global Commercial Market Driven

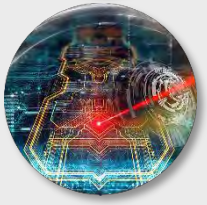
Naval Research Response

FRAMEWORK PRIORITIES

Augmented Warfighter

Integrated & Distributed Forces

Operational Endurance



Scalable Lethality

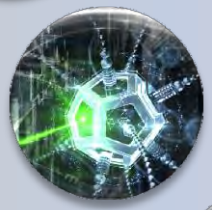
Sensing & Sense-Making

"…the tempo of modern war has reached the point where this Nation will probably never again have an opportunity to arm itself successfully after the start of hostilities…." *– Forrestal*

Research & Development Priorities

Five Framework Priorities that are Strategic and Warfighter-Focused…

Augmented Warfighter

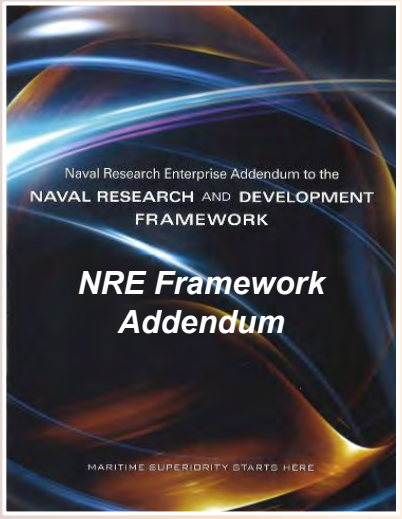


Integrated & Distributed Forces

Operational Endurance

Scalable Lethality

Sensing & Sense-Making



…Translates to Six Technology-Focused Integrated Research Portfolios

Amphibious Expeditionary Maneuver

Information, Cyber & Spectrum Superiority

Undersea Battlespace & Maritime Domain Access

Mission Capable, Persistent & Survivable Sea Platforms

Warfighter Supremacy

Aviation, Force Projection & Integrated Defense

55 Enduring Research Responsibilities

- EXPEDITIONARY FIRES AND LETHALITY
- EXPEDITIONARY C4ISR
- HYBRID THREAT DEFEAT
- HUMAN PERFORMANCE AND PROTECTION
- AMPHIBIOUS MOBILITY
- LOGISTICS, SUSTAINMENT AND MAINTENANCE
- EXPEDITIONARY POWER AND ENERGY
- LIGHTENING THE LOAD
- ACCELERATED LEARNING/DECISION-MAKING
- INFORMATION ENVIRONMENT OPERATIONS
- DIRECTED ENERGY (DE) & COUNTER DE
- AERODYNAMICS
- FLIGHT DYNAMICS & CONTROL
- PROPULSION
- STRUCTURES AND MATERIALS
- ENERGETIC MATERIALS
- HYPERSONICS
- AUTONOMY

- ADVANCED RF ELECTRONICS & MATERIALS
- COMMUNICATIONS AND NETWORKING
- COMPUTATIONAL METHODS FOR DECISION MAKING
- DATA SCIENCE AND ANALYTICS
- ELECTRONIC WARFARE
- SENSORS AND SENSOR PROCESSING
- MACHINE LEARNING, REASONING AND INTELLIGENCE
- RESOURCE OPTIMIZATION
- PRECISION NAVIGATION & TIMEKEEPING
- UNDERSEA MEDICINE
- BIOLOGICAL SCIENCES
- BIOROBOTICS
- CAPABLE MANPOWER
- COMMAND DECISION MAKING
- FORCE HEALTH PROTECTION
- HUMAN-ROBOT INTERACTION
- NOISE-INDUCED HEARING LOSS
- TRAINING AND SIMULATION

- ARCTIC AND GLOBAL PREDICTION
- LITTORAL GEOSCIENCES AND OPTICS
- MARINE MAMMALS AND BIOLOGY
- MARINE METEOROLOGY
- MARITIME SENSING
- OCEAN ACOUSTICS
- OCEAN ENGINEERING & MARINE SYSTEMS
- PHYSICAL OCEANOGRAPHY
- RESEARCH FACILITIES
- SPACE ENVIRONMENT
- UNDERSEA SIGNAL PROCESSING
- NAVAL ENGINEERING
- ADVANCED NAVAL POWER SYSTEMS
- ADVANCED SURVIVABLE SEA PLATFORMS
- UNMANNED SEA PLATFORMS, AUTONOMY AND POWER
- ADVANCED NAVAL MATERIALS
- UNDERSEA WEAPONS, COUNTER-WEAPONS AND ENERGETICS
- SEA PLATFORM ENVIRONMENTAL QUALITY
- CORROSION CONTROL

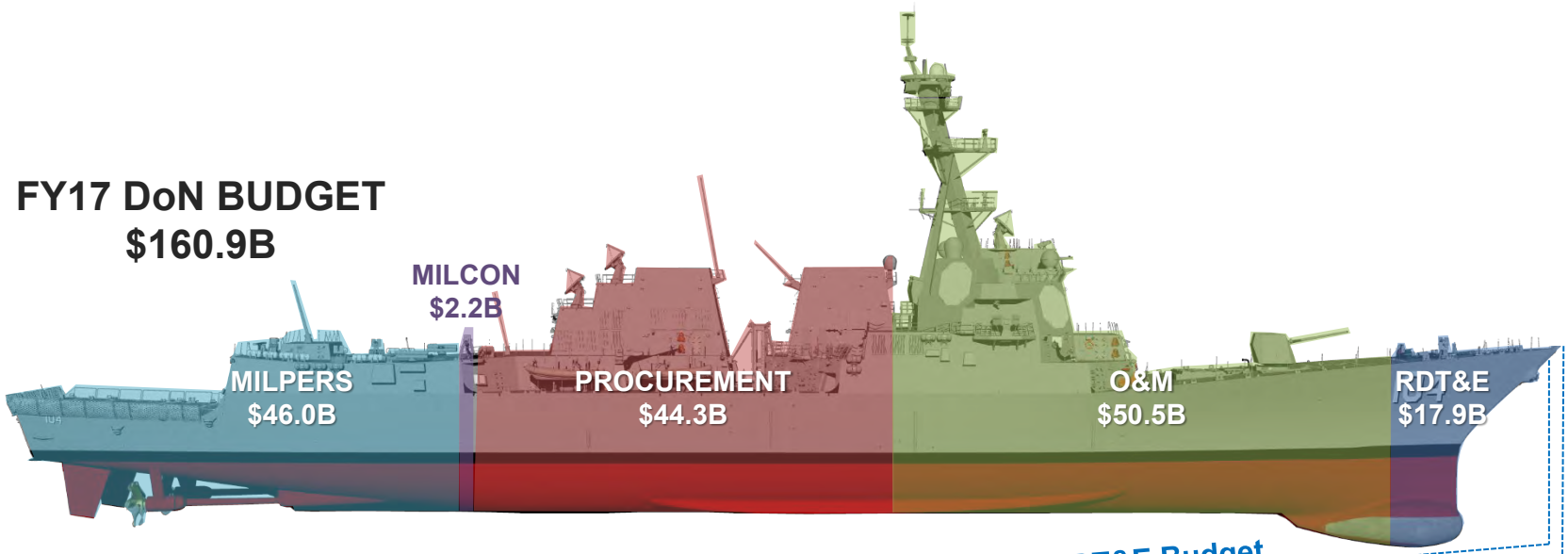
Getting to Capability

The ONR Portfolio is Broad Yet Singularly Focused on Delivering Continued Naval Superiority

$37M	**Demonstration and Validation**	Efforts that have moved into the development and integration of hardware for field experiments and tests.
$879M	**Advanced Technology Development**	Evaluation of integrated technologies in as realistic an operating environment as possible to assess the performance or cost reduction potential.
$956M	**Applied Research**	Research to determine the means by which a recognized and specific need may be met.
$547M	**Basic Research**	Research without specific applications toward processes or products in mind.

FY17 Funding

The Portfolio Investment Relative to FY17 Navy Budget



Naval Research Enterprise Allotted $2.42B of FY17 RDT&E Budget

Basic Research $547M	Applied Research $956M	Advanced Technology Development $879M	

Demonstration and Validation $37M

The Naval Research Enterprise











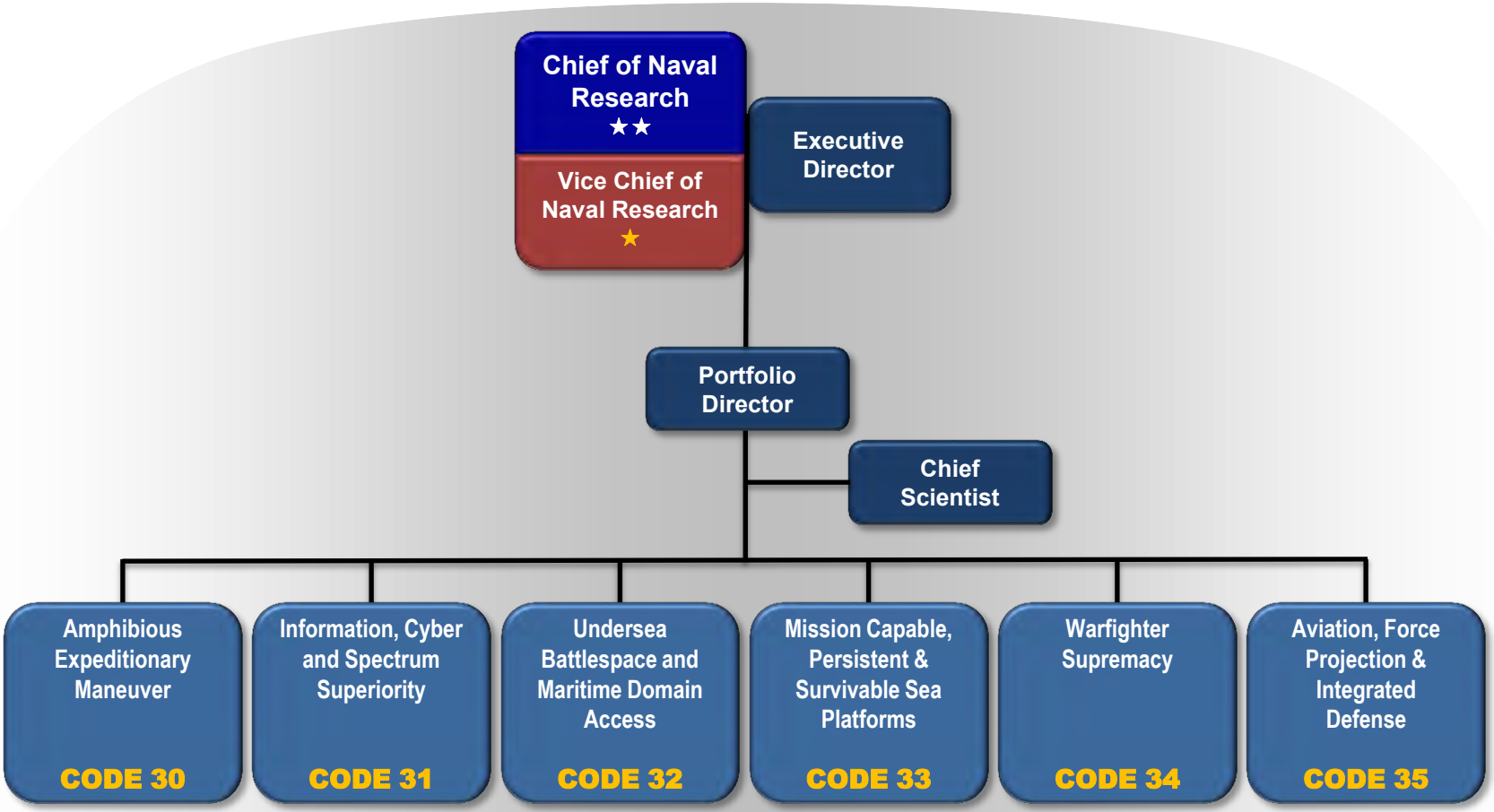
ONR HQ

U.S. NAVAL RESEARCH LABORATORY
NRL

ONR Global

4,000+ People
23 Locations
$2.1B / year
>1,000 Partners

ONR Headquarters



Managing the Portfolio

Naval Research Laboratory

- *The Navy's Corporate Laboratory*
- *World Class Research Team*
- *Basic and Applied Research and Advanced Technology Development for Anticipated Navy and Marine Corps Needs*

PEO IWS

NASA

Office of Naval Research ONR Science & Technology

SPAWAR

PEO SHIPS

DARPA

U.S. ARMY

NAVSEA NAVAL SEA SYSTEMS COMMAND

Directly Funded Work

$$$

U.S. NAVAL RESEARCH LABORATORY

Research Focus Areas

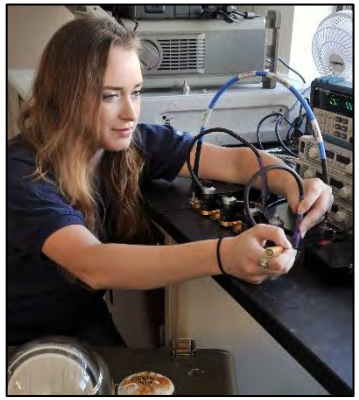
NRL Basic & Applied Research

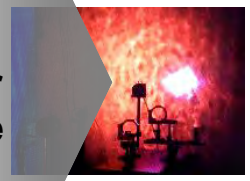
$

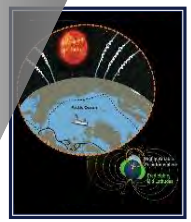
Integrated Research Portfolio

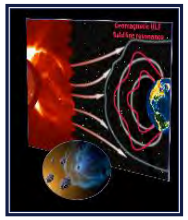
Delivering Warfighter Advantage

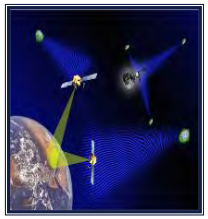
NRL Products & Prototypes



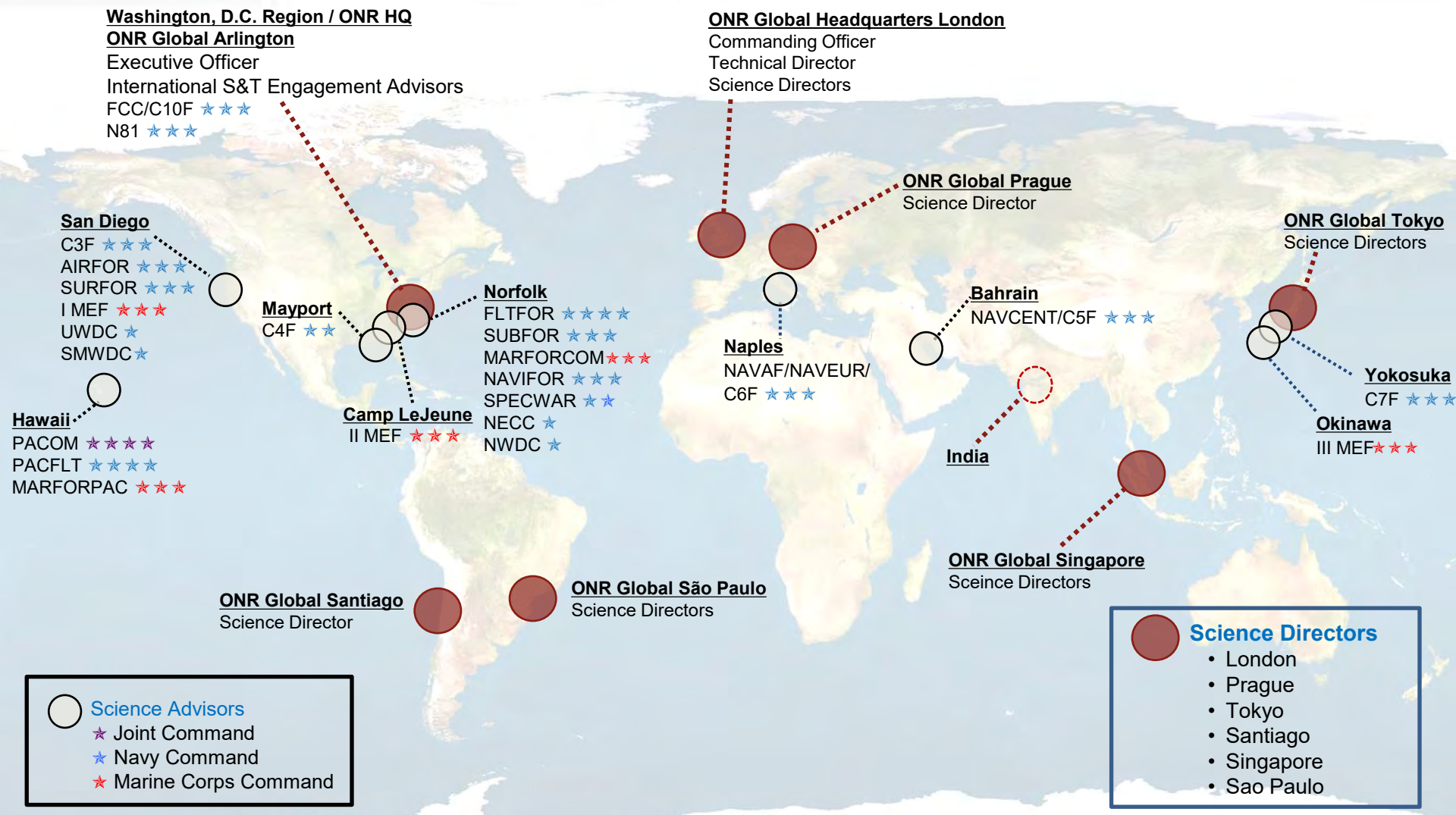








ONR Global



ONR's Global Offices are the Bridge to International Partnership; Naval R&D Diplomacy in More than 60 Countries

Complex Operating Environment

Contested Urban Environment

Area Description

Complex terrains:

- Crowded and cluttered physical, human, communication, and informational environment
- Physical compartmentalization and additional dimensions
- Proliferation of observation and fires technologies
- Threat obscuration

Technical Approach

- Urban fires and weapons
- Urban mobility
- Urban communication
- Threat sensing, detection, and prevention
- Urban survivability

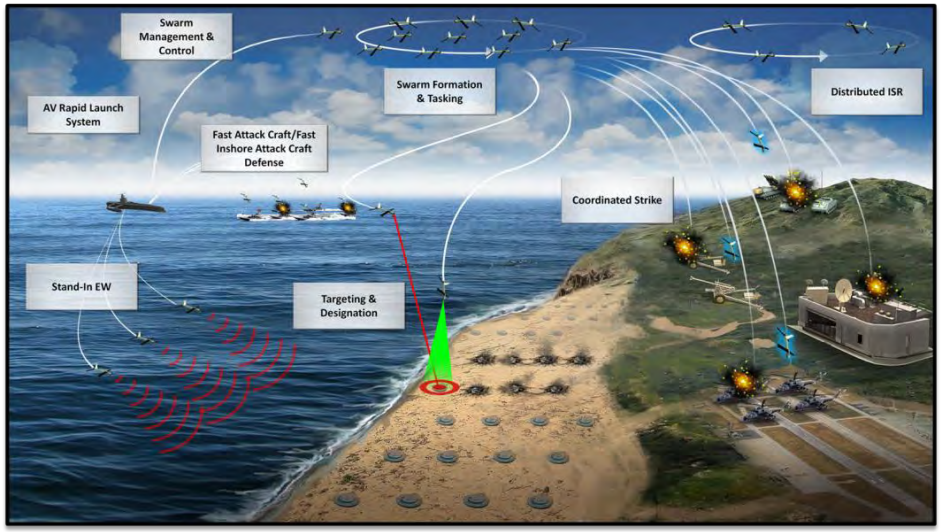
Cooperative Autonomy

Area Description

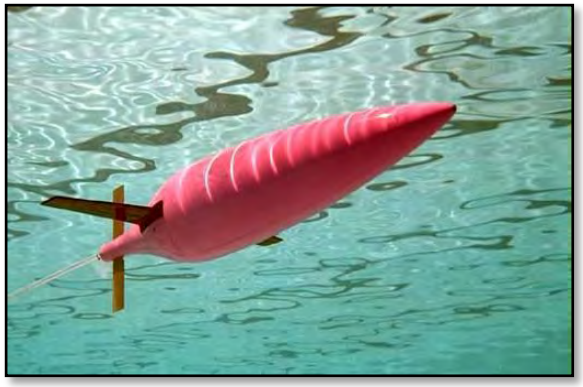
- Extend reach, increase mass and quantity, and augment the capability of expeditionary forces
- Allow penetration of environments too dangerous for manned systems
- Retain capability despite combat losses with automatic and flexible unmanned adjustment
- Disperse capabilities associated with traditional capital assets

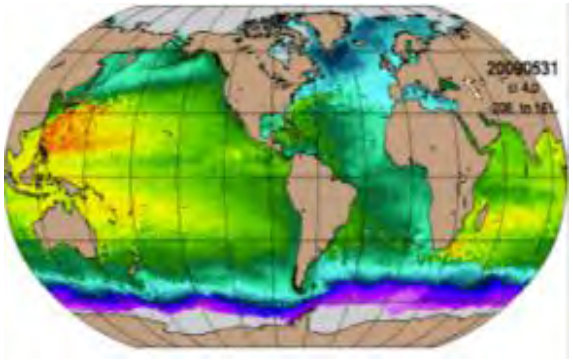
Technical Approach

- Low cost ground, air, and amphibious autonomous systems
- Distributed, collaborative, coordinated and cognitive autonomy
- Autonomous sensing, obstacle detection and path planning
- Unmanned C4 and control theory
- Manned-unmanned teaming



Undersea Autonomous Systems

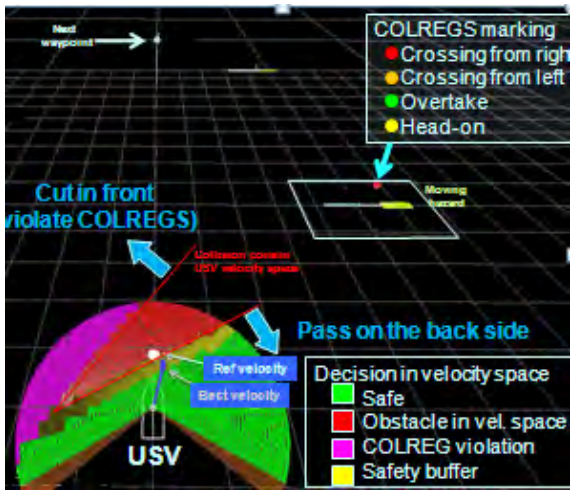


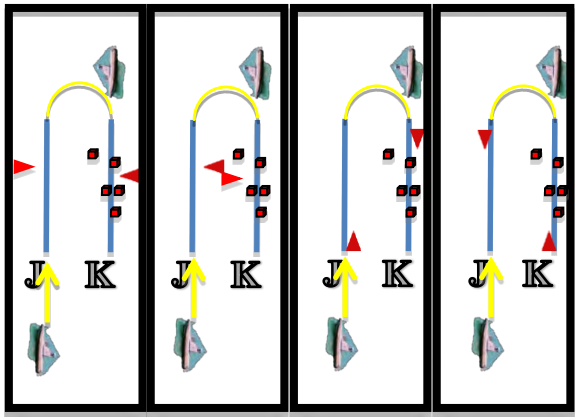


Goals

- Mobile autonomous environmental sensing
- Predictive capabilities
- Adapt systems to environmental variability

Autonomous Surface Vehicles

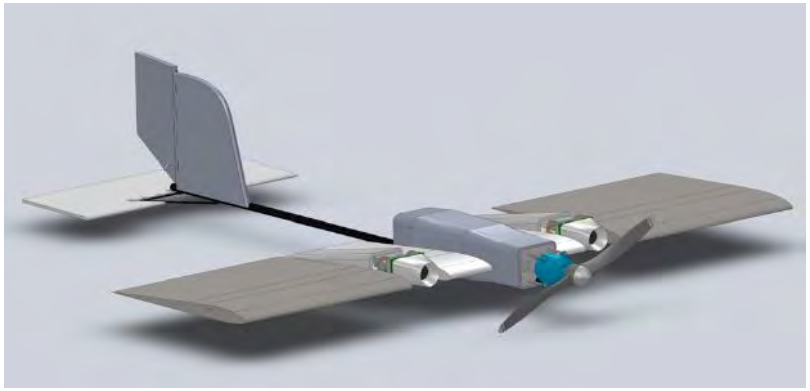




Goals

- Perform complex tasks in a complex environment, without human intervention
- Respond effectively to dynamic situations
- Perceive environment, internal and external

Aerial Autonomous Systems



Goals

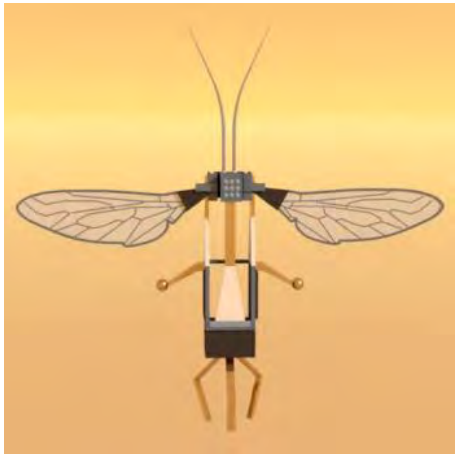
- Safe operation in the maritime/shipboard environment
- Effective collaboration with humans
- Increased role with greatly reduced need for human intervention

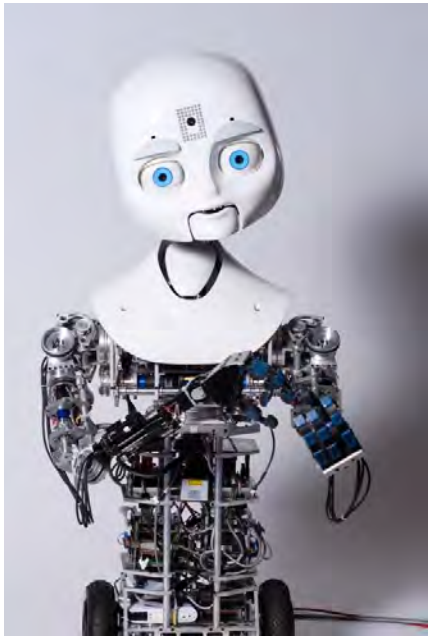
Expeditionary Autonomy

Goals

- Affordable platform agnostic modular Autonomy kits for current and future fleet vehicles
- Seamless & natural visual and verbal human-robot interaction
- Multi-platform collaboration

Novel Systems





Goals

- Multi domain platforms
- Fundamental understanding of the hydrodynamics of high efficiency bio-inspired underwater propulsion
- Compact, low-power perception and mapping for nano-UAVs
- Muscle-like actuators and multifunction material control surfaces (undersea and air)

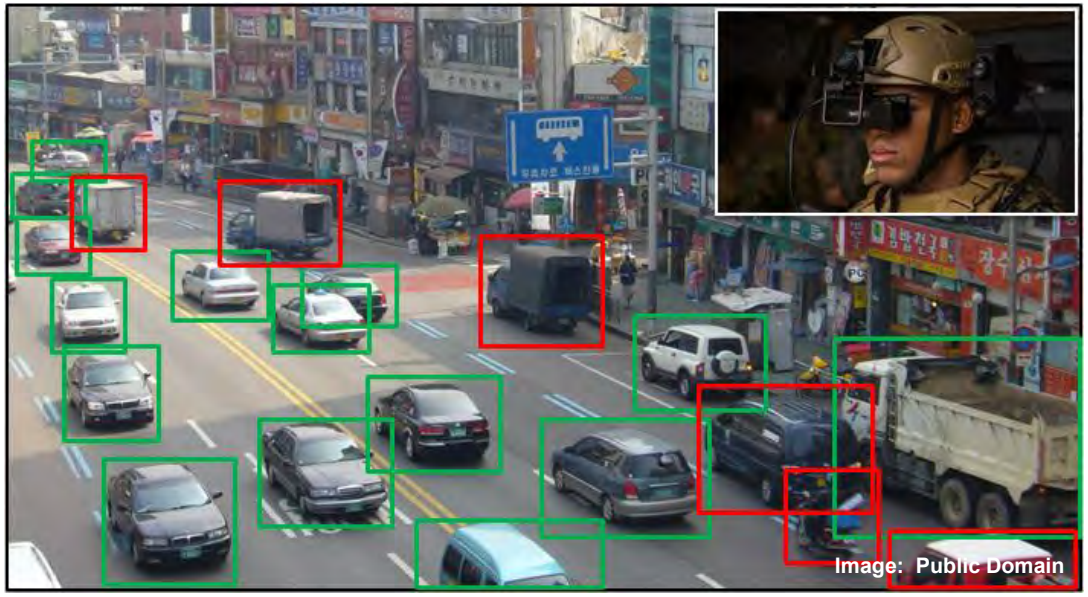
Cognitive Advantage and Artificial Intelligence

Area Description

- Meld machine intelligence and human decision making Ground warrior advanced decision support
- Enhance warfighter sensing, cognitive speed, and decision superiority
- True, rapid, all-source data fusion
- Knowledge products delivered to the warfighter with real world context

Technical Approach

- Data science and analytics
- Image classification
- On-board processing
- Augmented Reality
- Visual attention models



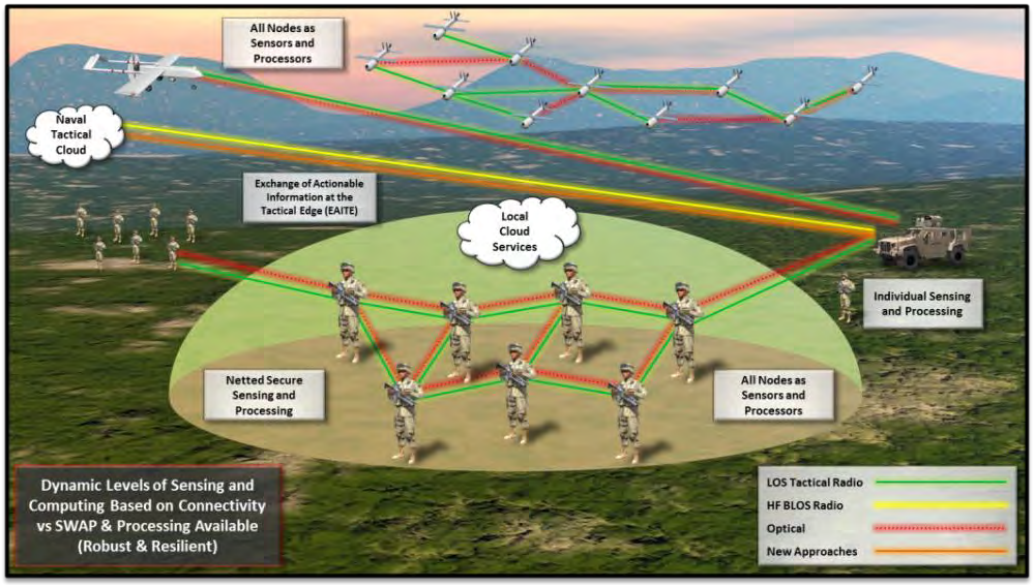
Expeditionary Communications and Cyber

Area Description

- Resilient, robust, and secure communications
- Cyber and information warfare capability
- Electromagnetic signature control and influence
- Rapidly changing network conditions amidst battle of signatures and physical movement
- Exploits close physical proximity while mitigating connectivity shortfalls

Technical Approach

- Networked and local computational availability
- Non-GPS precision, navigation, timing
- Antennas and propagation
- Communications and information theory
- Communications signal processing



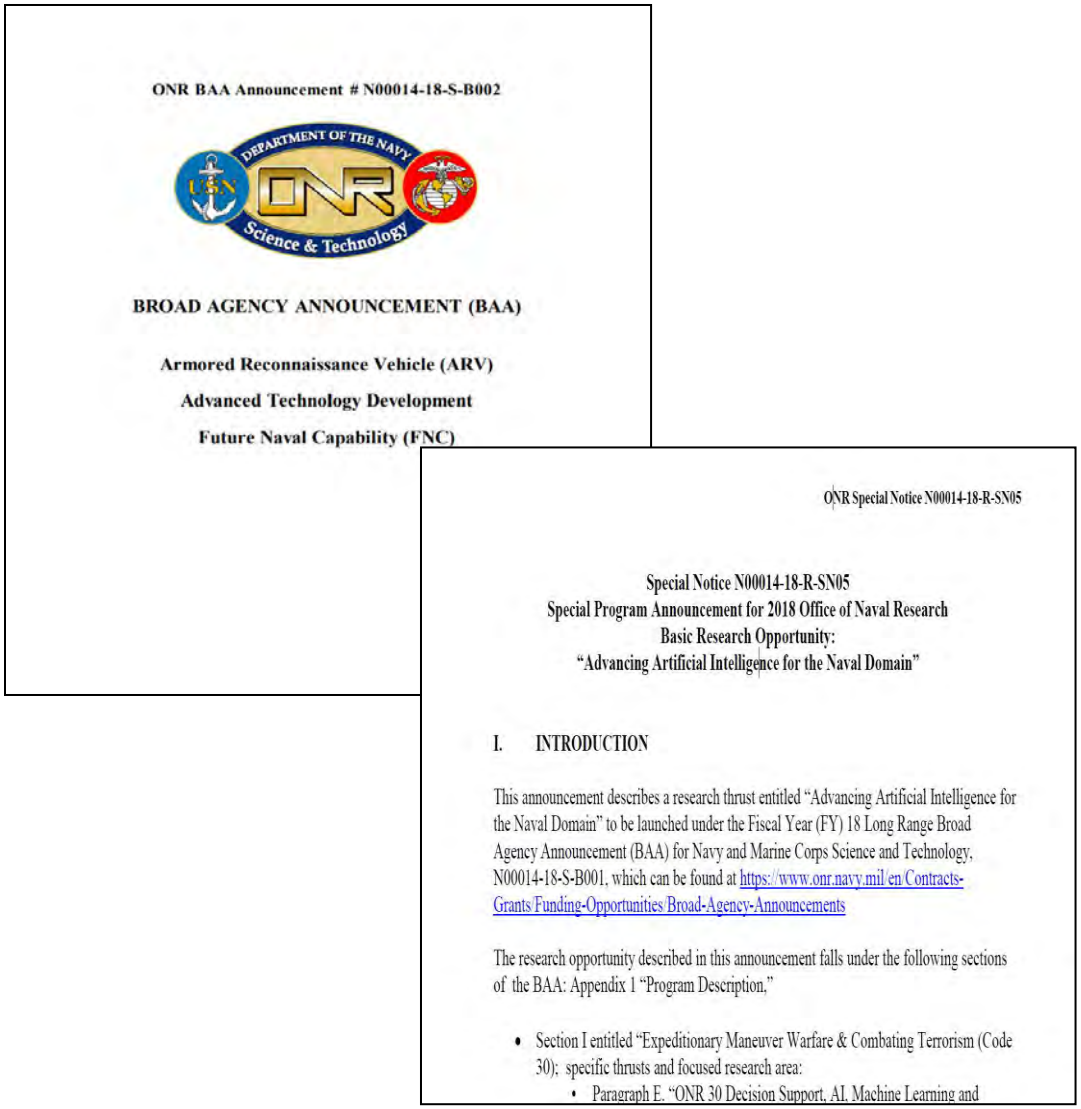
Signature Visualization

2/6 S-2 in Bn COC at FEX II (Dec 2016)

USC ICT Aerial Terrain Line of sight Analysis System

https://www.youtube.com/watch?v=-spEV8dkuOY

Opportunities



ONR BAA Announcement # N00014-18-S-B002

BROAD AGENCY ANNOUNCEMENT (BAA)

Armored Reconnaissance Vehicle (ARV)

Advanced Technology Development

Future Naval Capability (FNC)

ONR Special Notice N00014-18-R-SN05

Special Notice N00014-18-R-SN05
Special Program Announcement for 2018 Office of Naval Research
Basic Research Opportunity:
"Advancing Artificial Intelligence for the Naval Domain"

I. INTRODUCTION

This announcement describes a research thrust entitled "Advancing Artificial Intelligence for the Naval Domain" to be launched under the Fiscal Year (FY) 18 Long Range Broad Agency Announcement (BAA) for Navy and Marine Corps Science and Technology, N00014-18-S-B001, which can be found at https://www.onr.navy.mil/en/Contracts-Grants/Funding-Opportunities/Broad-Agency-Announcements

The research opportunity described in this announcement falls under the following sections of the BAA: Appendix 1 "Program Description,"

- Section I entitled "Expeditionary Maneuver Warfare & Combating Terrorism (Code 30); specific thrusts and focused research area:
  - Paragraph E. "ONR 30 Decision Support, AI, Machine Learning and

Advancing Artificial Intelligence for the Naval Domain –

22 March

Armored Reconnaissance Vehicle. Full Proposals-

April 2

Long Range BAA

Staying In Touch

www.onr.navy.mil

YouTube

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